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MEASURE CHARACTERIZATION

Portable Air Conditioner and Heat Pump, Residential

https://www.caetrm.com/measure/SWAP020/01-draft/

USE CATEGORY
AP - Appliance or Plug Load

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Technology Summary

A portable air conditioner (AC) is a factory-encased air conditioner that is designed for spot cooling an individual room rather than a whole house. Portable AC units with wheels and an exhaust hose can be easily placed in most windows. These features make it easy to move a portable AC unit between rooms quickly, satisfying changing cooling requirements as needed. This reduces energy demand by decreasing the total space served by air conditioning when compared to central AC units which can also serve mostly unoccupied spaces. Some portable AC units are also designed to provide heating through integrated electric resistance coils. A portable heat pump (HP) fills an identical role, but more efficiently provides heating through the use of a reversing valve which allows for the refrigerant cycle to transfer heat indoors instead of moving heat outdoors. Newer models of portable ACs and HPs can also have wireless controls capabilities which allow them to be programmed and/or scheduled through online websites, mobile phone applications, or smart home systems.

A Portable Air Conditioner Installed

The energy efficiency of a portable AC unit is represented by the combined energy efficiency ratio (CEER). The CEER is the ratio of measured cooling output (Btu/hr) to the sum of the measured average annual electrical energy input (watts) and measured annual standby/off-mode energy input (watts). CEER is expressed in Btu/W-hr.

Title 20 minimum efficiencies use the CEER metric and vary based on Seasonal Adjusted Cooling Capacity (SACC). The SACC is a metric that was developed by the US Department of Energy (DOE) and applies to portable air conditioners manufactured after October 1, 2017. [R286] The SACC is a rating in Btu/hr that represents the weighted average performance of the portable air conditioner in a various test conditions, including some that are more extreme than the average use case, which is then adjusted to account for the effect of infiltration air and duct heat transfer. ASHRAE also provides test methods for reporting cooling capacities but those differ from the DOE method.

As part of the 1990 Clean Air Act Amendment, the US Environmental Protection Agency (EPA) launched the Significant New Alternatives Program (SNAP) which focuses on acceptable alternatives to harmful chemicals with regard to atmospheric effects, human health and safety, flammability, and environmental impacts. As part of this program, the EPA provides lists of low ozone depletion potential (ODP) and low global warming potential (GWP) refrigerants that are used in refrigeration and air conditioning systems. While many commonly used refrigerants are not on this list, some, including HFC-32 (R-32), R-441A, and propane (R-290), have been listed as acceptable substitutes for use in small air condition systems. R2228

Measure Case Description

There is no Energy Star Qualified Products List for portable ACs or HPs. The measure case equipment must exceed Title 20 Code efficiency by 5% or more and use a SNAP listed refrigerant with a GWP of 1,000 or less. Connected controls are required for some offerings as well. See the Program Requirements section for additional details on identifying qualifying products.

Offering ID

MEASURE CASE EQUIPMENT	MEASURE APPLICATION TYPE	STATEWIDE MEASURE OFFERING ID (TEXT)	MEASURE OFFERING DESCRIPTION (TEXT)
Portable Air Conditioners	NC	**A**	**Efficient portable air conditioner, CEER 5% greater than T20 standard**
Portable Air Conditioners	NR	**A**	**Efficient portable air conditioner, CEER 5% greater than T20 standard**
Portable Air Conditioners with Connected Controls	NC	**B**	**Efficient portable air conditioner with connected controls, CEER 5% greater than T20 standard**
Portable Air Conditioners with Connected Controls	NR	**B**	**Efficient portable air conditioner with connected controls, CEER 5% greater than T20 standard**
Portable Heat Pumps	NC	**C**	**Efficient portable heat pump, CEER 5% greater than T20 standard**
Portable Heat Pumps	NR	**C**	**Efficient portable heat pump, CEER 5% greater than T20 standard**
Portable Heat Pumps with Connected Controls	NC	**D**	**Efficient portable heat pump with connected controls, CEER 5% greater than T20 standard**

MEASURE CASE EQUIPMENT	MEASURE APPLICATION TYPE	STATEWIDE MEASURE OFFERING ID (TEXT)	MEASURE OFFERING DESCRIPTION (TEXT)
Portable Heat Pumps with Connected Controls	NR	**D**	**Efficient portable heat pump with connected controls, CEER 5% greater than T20 standard**

Base Case Description

The minimum efficiencies for portable ACs and HPs is governed by California Appliance Efficiency Standards (Title 20). The base case is defined as a T20 minimum CEER unit for all measure application types. Note, that the T20 CEER minimum varies by SACC.

Base Case Descriptions

MEASURE CASE EQUIPMENT	MEASURE APPLICATION TYPE	STATEWIDE MEASURE OFFERING ID (TEXT)	EXISTING CASE DESCRIPTION (TEXT)	STANDARD CASE DESCRIPTION (TEXT)
Portable Air Conditioners	NC	**A**	**Home with no HVAC**	**Standard portable air conditioner, T20 CEER**
Portable Air Conditioners	NR	**A**	**Standard portable air conditioner, T20 CEER**	**Standard portable air conditioner, T20 CEER**
Portable Air Conditioners with Connected Controls	NC	**B**	**Home with no HVAC**	**Standard portable air conditioner, T20 CEER**
Portable Air Conditioners with Connected Controls	NR	**B**	**Standard portable air conditioner, T20 CEER**	**Standard portable air conditioner, T20 CEER**
Portable Heat Pumps	NC	**C**	**Home with no HVAC**	**Standard portable heat pump, T20 CEER**
Portable Heat Pumps	NR	**C**	**Standard portable heat pump, T20 CEER**	**Standard portable heat pump, T20 CEER**
Portable Heat Pumps with Connected Controls	NC	**D**	**Home with no HVAC**	**Standard portable heat pump, T20 CEER**
Portable Heat Pumps with Connected Controls	NR	**D**	**Standard portable heat pump, T20 CEER**	**Standard portable heat pump, T20 CEER**

Code Requirements

As shown below, portable air conditioners are governed by California Appliance Efficiency Regulations (Title 20) and Federal Regulations. R1581 R286 Portable HPs are not explicitly mentioned under either code, but must still meeting minimum CEER requirements in cooling mode. Furthermore, the refrigerants that are used in the portable ACs and HPs are reviewed by the EPA SNAP program to qualify as low GWP.

Applicable State and Federal Codes and Standards

CODE	CODE REFERENCE	EFFECTIVE DATE
CA Appliance Efficiency Regulations – Title 20	Section 1605.3 (d)	February 1, 2020
CA Building Energy Efficiency Standards – Title 24	None.	n/a
Federal Standards – Code of Federal Regulations	10 CFR Part 429.62 10 CFR Part 430, Subpart B, Appendix CC	June 1, 2016
U.S. Environmental Protection Agency (EPA) - Significant New Alternatives Policy Program (SNAP)	40 CFR, Appendix R to Subpart G of Part 82	April 10, 2015

Title 10 of the Code of Federal Regulations

Section 429.62 of the CFR requires that all portable ACs manufactured after July 1, 2016 comply with the test method described in Appendix CC to subpart B of Part 430, which provides the methodology to calculate the SACC and CEER of portable ACs.

For SACC values, the test method measures cooling capacities and losses due to infiltration rates and duct heat transfer, assuming two different outdoor air conditions; one at 83 °F dry bulb and one at 95 °F dry bulb. It subtracts these losses from the tested capacities to find adjusted cooling capacities. Lastly, it weights the adjusted capacities based on the formula below.

$$SACC = (ACC_{95} * 0.2) + (ACC_{83} * 0.8)$$

ACC_{95} = Adjusted cooling capacity of tests using 95 °F outdoor air (Btu/hr)
ACC_{83} = Adjusted cooling capacity of tests using 83 °F outdoor air (Btu/hr)

For CEER values, the test method measures the power used by the portable AC in active cooling mode at both outdoor air temperatures, off-cycle (standby) mode, and inactive/off mode. It then multiplies each power by an assumed annual operating hours per mode to find an annual energy consumption value per unit.

Operating Hours from Section 5.3 of Test Method

OPERATING MODE	ANNUAL OPERATING HOURS
Cooling Mode, Dual-Duct 95 °F	750
Cooling Mode, Dual-Duct 83 °F	750
Cooling Mode, Single-Duct	750
Off-Cycle	880
Inactive or Off	1,355

Lastly, it divides the SACC by the calculated energy consumption values at the various operating conditions. The CEER calculations vary slightly between single-duct and dual-duct systems.

$$CEER_{SD} = \left[\frac{(ACC_{95} \times 0.2 + ACC_{83} \times 0.8)}{\left(\frac{AEC_{SD} + AEC_T}{k \times t} \right)} \right]$$

CFR CEER Formula - Single Duct

$$CEER_{DD} = \left[\frac{ACC_{95}}{\left(\frac{AEC_{95} + AEC_T}{k \times t} \right)} \right] \times 0.2 + \left[\frac{ACC_{83}}{\left(\frac{AEC_{83} + AEC_T}{k \times t} \right)} \right] \times 0.8$$

CFR CEER Formula - Dual Duct

> ACC_{95} = *Adjusted cooling capacity of tests using 95 °F outdoor air (Btu/hr)*
> ACC_{83} = *Adjusted cooling capacity of tests using 83 °F outdoor air (Btu/hr)*
> AEC_{SD} = Annual energy consumption in cooling mode for single-duct portable air conditioners (kWh/yr)
> AEC_{95} = annual energy consumption for dual-duct portable air conditioners *95 °F outdoor air* (kWh/yr)
> AEC_{83} = annual energy consumption for dual-duct portable air conditioners 83 *°F outdoor air* (kWh/yr)
> *t = number of cooling mode hours per year, 750*
> *k = 0.001 kWh/Wh conversion factor for watt-hours to kilowatt-hours*

California Title 20 Requirements for Portable Air Conditioners

Section 1605.3(d)1 of Title 20 requires that the CEER for all portable AC units manufactured on or after February 1, 2020 meet or exceed the value calculated from the equation below, based on SACC.

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CEER = 1.04 * SACC / (3.7117 * SACC^0.6384)
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SACC = Seasonal Adjusted Cooling Capacity (Btu/hr)

U.S. Environmental Protection Agency (EPA) - Significant New Alternatives Policy (SNAP) Program

The SNAP program was established under Section 612 of the Clean Air Act to identify and evaluate substitutes for ozone-depleting substances. The program looks at overall risks to human health and the environment of existing and new substitutes, publishes lists and promotes the use of acceptable substances, and provides the public with information.

The Substitutes in Residential and Light Commercial Air Conditioning and Heat Pumps webpage provides a live list of alternative refrigerants approved by the program for use in specific HVAC applications. R2228 The list provides the ozone depletion potential (ODP) and global warming potential (GWP), as well listing dates, ASHRAE safety designation, and notes on applicability. For portable heat pumps, the most relevant refrigerants on the list is are R-410A and HFC-32, a.k.a. R-32. R-32 was first listed as an acceptable substituted in 40 CFR, Appendix R to Subpart G of Part 82 on April 10, 2015 and can be readily found in the market of portable ACs and HPs. R-32 has a lower GWP than compared to R-410A, its other SNAP labelled competitor in the portable AC and HP market. R1613

Environmental Factors of SNAP Approved Refrigerants

REFRIGERANT	ODP	GWP - 100YR
R-32	0	675
R-410A	0	2090

Program Requirements

MEASURE IMPLEMENTATION ELIGIBILITY

All measure application type, delivery type, and sector combinations that are established for this measure are specified below. Measure application type is a categorization based on the circumstances and timing of the measure installation; each measure application type is distinguished by its baseline determination, cost basis, eligibility, and documentation requirements. Delivery type is the broad categorization of the delivery channel through which the market intervention strategy (financial incentives or other services) is targeted. This table also designates the broad market sector(s) that are applicable for this measure.

Implementation Eligibility

MEASURE APPLICATION TYPE	SECTOR	DELIVERY TYPE
NC	Res	DnDeemDI
NC	Res	DnDeemed
NC	Res	UpDeemed
NR	Res	DnDeemDI
NR	Res	DnDeemed
NR	Res	UpDeemed

ELIGIBLE PRODUCTS

Since Title 20 code minimum CEER efficiencies are dependent upon SACC, the minimum qualifying measure case efficiencies will also vary by SACC and should be confirmed for each product. The formula below can be used to confirm the minimum qualifying CEER for a specific SACC.

$$CEER_{Qualifying} = 1.05 * (1.04 * SACC / (3.7117 * SACC^{0.6384}))$$

SACC = Seasonal Adjusted Cooling Capacity (Btu/hr)

Alternatively, the qualifying for a specific product can be found by multiplying the value in the "Combined Energy Efficiency Ratio (CEER) in Btu/Wh Standard" column from the Title 20 appliance database qualifying product list by 105%. Minimum qualifying CEER values should be rounded to the nearest tenth to align with DOE standards.

In addition to meeting the measure case requirements (see Measure Case Description), the following eligibility requirements apply:

- For measures noted as “Connected” the product should have some ability to wirelessly connect to a smart home system (Alexa, Google Home, Apple Home, etc.), website, or mobile phone application. There are no specific requirements for demand response enabled controls at this time.
- The portable AC/HP must use an EPA SNAP listed refrigerant for this application and have a 100 year GWP of 1,000 or lower. The current list can be found on the SNAP website, Substitutes in Residential and Light Commercial Air Conditioning and Heat Pump page. R2228
- The portable AC/HP must be UL certified for relevant UL safety standards by a Nationally Recognized Testing Laboratory (NRTL).

- The portable HP must not use electric resistance heat as the primary heating source.
- Both single-duct and dual-duct products are eligible, as long as they meet all other product requirements.
- In order to claim normal replacement (NR), the measure case portable AC/HP must replace an existing portable AC/HP or a room AC/HP. If no existing portable or room AC/HP exists, then new construction (NC) must be claimed.

ELIGIBLE BUILDING TYPES AND VINTAGES

This measure is applicable for all residential building types (single-family, multifamily, and mobile homes) of existing vintages.

ELIGIBLE CLIMATE ZONES

This measure is applicable in all California climate zones.

Program Exclusions

All nonresidential building types are excluded from this measure.

Equipment using refrigerants not included on the EPA SNAP list are not eligible.

Data Collection Requirements

To ensure that the appropriate incentives, savings, and cost-effectiveness values are applied for each application/project, the following data must be collected for each application/project: R2026

MEASURE CASE EQUIPMENT SPECIFICATIONS INCLUDE
Equipment manufacturer
Equipment model number
Equipment Type (Air Conditioner or Heat Pump)

MEASURE CASE EQUIPMENT SPECIFICATIONS INCLUDE
Seasonally adjusted cooling capacity, SACC (BTU/hr)
Rated efficiency unit, CEER (Btu/W-hr)

CUSTOMER SITE IFORMATION INCLUDING:
Building Location
Building Type

Per *DEER Resolution E-5221*, the following site information data must be collected for all claims of all delivery types: R2026

PROGRAM DATA FOR ALL DELIVERY TYPES
SiteID - A unique identifier for the shipping destination (upstream) or installed location (midstream) of the incentivized equipment (e.g., site address)
EquipmentID - A unique identifier for each unit of incentivized equipment (e.g., serial number)
Quantity of installed portable air conditioning units
Invoice of project or cost of installed products

Electric Savings (kWh)

The unit energy savings (UES) for this measure was calculated as the difference between baseline and measure case annual energy consumption (AEC) modelled in Database for Energy Efficient Resources (DEER) version 2024 EnergyPlus prototype building models. The baseline prototype models for vintage 1985 one-story single-family (SFm1), two-story single-family (SFm2), multifamily (MFm) buildings, and double-wide mobile home (DMo) with standard efficiency packaged terminal air conditioners (PTAC) and heat pumps (PTHP) were altered to simulate the specific base and measure case systems in this measure package. R2183 R2226 R2227

The analysis utilized the ModelKit scripts provided by the DEER team to make parametric adjustments to the baseline prototypes. For all models, the following parameters were exported on either an hourly or annual basis to calculate the savings.

- Annual energy consumption (AEC) building consumption in kWh and therms
- Total HVAC system cooling capacity in tons

The following sections describe the updates made for each baseline and measure case in more detail.

The selected prototype models used PTAC and PTHP systems. These prototypes were selected because, as zone level equipment, they were expected to share similar specifications and operating profiles as portable ACs and HPs. Due to these similarities, the only updates made to the prototype models involved updates to the cooling and heating efficiencies and capacities. The Title 20 appliance database was used to inform several analysis values and decisions regarding unit efficiencies and representative capacities.

COEFFICIENT OF PERFORMANCE (COP)

Although the base and measure case portable ACs and HPs are rated based on CEER values, these values cannot directly be used in EnergyPlus. The software uses COP values to establish the efficiencies of the heating and cooling coil objects. An analysis of the Title 20 database was conducted to establish relevant COP values. R2183 (Representative Sizing and COP tab)

First, equipment that was 5% more efficient than the Title 20 data minimum value was identified as measure case equipment and all other equipment was noted as standard case. Next, equipment that was noted as having heating features were identified as heat pumps. Next, the tested capacity (Btu/hr) at the 83 °F test scenario was divided by the measured power from the 83 °F test scenario and a conversion factor to calculate the cooling COP. The 83 °F scenario was selected for the COP calculation because both single-duct and dual-duct systems provided this information.

$$\text{Estimated COP} = \text{Capacity}_{83} / (P_{83} * 3412 \text{ Btu/hr/W})$$

$Capacity_{83}$ = Capacity from 83 °F test scenario
P_{83} = Power from the 83 °F test scenario

Since there are no federal or Title 20 reporting requirements for portable HP heating efficiency, publicly available data is scarce. Based on the online retailer data retrieved through the costing analysis, it was found that heating capacities for portable HPs are often lower than the cooling capacities. The dataset from the costing analysis showed that on average the HP heating capacity was 77% of the cooling capacity. R2182

This relationship is the inverse than what is expected for some other HP systems. The measure developers suspect that it is because the test method used to establish the heating capacities requires a larger temperature differential than when testing for cooling capacities. For example, DOE specified test methods for dual duct portable HPs maintain the condenser inlet air temperature at 95 °F for cooling mode and 47 °F for heating mode. The evaporator inlet temperature (which, for dual duct portable HPs is equivalent to the room temperature) is 80.6 °F for cooling mode and 70 °F for heating mode. This correlates to a higher temperature difference for heating mode (of 14.4 °F for cooling and 23 °F for heating), which would lead to a lower system output capacity. R2232

Since HPs use the same compressors system for both heating and cooling, this analysis assumes that the power of the HP systems is the same in both heating and cooling mode (when no electric resistance is operating). Therefore, this analysis assumes that both the heating COP and heating capacity values for HPs are 77% of the cooling values. The analysis also showed that on average the HP equipment was more efficient at cooling than the AC equipment. Due to this the percent increase in COP between base and measure case equipment was lower for the HP equipment. The average COP values calculated for standard and efficient AC and HP equipment in the Title 20 database and used in the EnergyPlus modelling are shown in the table below.

Average AC and HP Coefficients of Performance (COP)

TYPE	AC	HP
AVERAGE COOLING COP - STANDARD EQUIPMENT	2.133	2.266
AVERAGE COOLING COP - MEASURE EQUIPMENT	2.274	2.332
DIFFERENCE IN COOLING COP	6.6%	2.9%
AVERAGE HEATING COP - STANDARD EQUIPMENT	N/A	1.745
AVERAGE HEATING COP - MEASURE EQUIPMENT	N/A	1.796
DIFFERENCE IN HEATING COP	N/A	2.9%

MODELLED SYSTEM CAPACITIES

The current EnergyPlus prototypes use HVAC systems that are autosized based on zone load. However, unlike permanent HVAC systems, which are designed and installed by professionals, portable systems are purchased and installed by the end user. Therefore, appropriate sizing of the HVAC systems is not expected to be the case in most installations. Undersizing systems can lead to extended run times and more unmet conditioned hours. Oversizing systems can lead to excessive cycling and increased energy use. In order to simulate the high chances of under or oversizing, systems in the DMo, SFm1, and SFM2 building types were hardsized as described in the table below. The hardsized systems for the DMo and SFm building types were selected based on the average sizes of the zones and a general rule of thumb of roughly 12 btu/hr per square foot for cooling loads in residential spaces. R2233 (Page 50) As mentioned above, HP heating capacities were assumed to be equal to 77% of the cooling capacities. Critical errors in the model occurred when hardsizing systems in the MFm building types and in CZ01 for the SFm building types. Therefore, those systems were left as autosized.

Modelled Capacities for Portable ACs and HPs

BUILDING TYPE	COOLING CAPACITY (TONS)	HEATING CAPACITY, IF APPLICABLE (TONS)
Dmo	0.50	0.385
SFm1	1.00	0.77
SFm2	1.00	0.77
MFm & SFm1/SFm2 in CZ01	Autosized	Autosized

NORMALIZATION

Total annual energy consumption and total cooling coil capacities in tons were exported from EnergyPlus for each base and measure case model. The difference in energy consumption values for each base case and measure case combination were calculated per building type and climate zone to calculate the whole model energy savings. These savings values were next normalized by the total cooling coil tonnage per model to provide a normalized savings per ton associated with each measure. R2183 (HVAC Capacities tab)

A representative cooling capacity of 8,000 Btu/hr (2/3 of a ton) was selected after a review of models available in the Title 20 database and the available products found in the cost analysis. R2182 R2183 (Representative Sizing and COP tab) The per ton savings values were multiplied by the representative portable AC and HP cooling capacity to find the final per unit savings values. R2183 (Savings Summary tab)

	Title 20 Data			Cost Analysis Data
SACC (Btu/hr)	AC Qty	HP Qty	AC + HP Qty	AC + HP Qty
4,000	14	0	14	5
5,000	179	14	193	34
6,000	192	27	219	50
7,000	111	18	129	39
8,000	**163**	**125**	**288**	**82**
9,000	33	34	67	10
10,000	86	76	162	45
11,000	5	0	5	2
12,000	6	8	14	13

Distribution of Portable AC and HP Capacities

Peak Electric Demand Reduction (kW)

Peak electric demand reduction was calculated as the average of the electrical power draw between 4:00 p.m. to 9:00 p.m. in conformance with the Database for Energy Efficiency Resources (DEER) peak definition. Peak days were selected in accordance with *Resolution E-5152*. R1503 Savings were derived using the methodology presented in the Electric Savings section.

Gas Savings (Therms)

No therms savings are applicable.

Life Cycle

Effective Useful Life (EUL) is an estimate of the median number of years that a measure installed through a program is still in place and operable. EUL is often, but not always, derived from measure persistence or retention studies. 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.

No DEER EUL exists specifically for portable ACs or HP equipment. Therefore, the room AC EUL was selected to estimate the EUL of a portable ACs and HPs. Note that RUL is only applicable for add-on and accelerated replacement measures and not applicable for this measure.

Note that the original source for the estimated lifetime of a room AC unit was adopted in the Database for Energy Efficient Resources 2008 update, with the original source noted as "Appliance Magazine." Documentation for this EUL has not been located or is no longer available. R323

Effective Useful Life and Remaining Useful Life

EFFECTIVE USEFUL LIFE ID	EUL DESCRIPTION (TEXT)	SECTOR (TEXT)	EUL YEARS (YR)	START DATE (TEXT)	EXPIRE DATE (TEXT)
HV-RAC-ES	**Room AC - Energy Star**	**Res**	**9.00**	**2013-01-01**	

Base Case Material Cost ($/Unit)

The base case material costs were retrieved from a webscraping analysis conducted in the first quarter 2023 from major online retailers. The analysis collected over 340 data points from retailers such as Home Depot, Lowes, Best Buy, Amazon, and Walmart. The dataset included factors such as system type, model number, brand, price, SEER, SACC, heating capacity (if applicable), and notes on additional features. A deeper review of individual products was completed to identify what refrigerant the product used and whether it had connected capabilities. The list of products was then reviewed for cost outliers and models that were not included in the Title 20 appliance database. Official Title 20 SACC and CEER values were added to the dataset for models that were included in the Title 20 appliance database.

Pricing for retail appliances, such as portable ACs and HPs, are expected to vary based on a number of factors, such as system type, cooling or heating capacity, brand, efficiency, and additional features, such as web connectivity. This analysis first calculated the normalized cost per SACC (Btu/hr) in order to review the costs across various capacities more evenly. The following additional data points were calculated for each product.

- Efficiency Tier: If the product was at least 5% more efficient than its Title 20 minimum, it was assigned to the efficient tier, otherwise it was in the standard tier.
- Low GWP: If the product used R-32 refrigerant, it was noted to as low GWP. If it used R-410A, it was noted as standard refrigerant. No other refrigerant were identified in the dataset and not all product data showed what refrigerant was used. If no refrigerant data was available, the unit was assumed to be in the standard refrigerant category.
- Connected Features: If the product was noted to have connected features, such as wi-fi connectivity, "smart" features, the ability to be controls from an app, or other related features, it was noted as connected. Otherwise, it was noted as not connected.

A hedonistic pricing approach was used in order to review the incremental cost impact of each feature. First, the average normalized cost across various combinations of system type (AC/HP), efficiency (standard/efficient), low GWP refrigerant (Y/N), and connected features (Y/N) was conducted. Average values were calculated for datasets filtered by a single parameter, two parameters, three parameters, and all four parameters. When not relevant to the filtered parameters, all values were included. For example, if the filtered parameters were AC units with low GWP, both standard and efficient products, and connected and non-connected products were included in the average.

The normalized cost for both AC and HP systems, with standard efficiency, standard GWP refrigerant, and no connected features was used to calculate the base case material cost. This cost was multiplied by the representative equipment cooling capacity from the Title 20 appliance database analysis to find the base case material cost. R2182

Costs - Calculation Inputs

MEASURE CASE EQUIPMENT	STANDARD CASE NORMALIZED COST (USD / UNIT)	REPRESENTATIVE UNIT CAPACITY (BTU / HR)
Portable Air Conditioners	**$0.0647**	**8,000.00**
Portable Air Conditioners with Connected Controls	**$0.0647**	**8,000.00**
Portable Heat Pumps	**$0.0652**	**8,000.00**
Portable Heat Pumps with Connected Controls	**$0.0652**	**8,000.00**

First Base Case Material Cost

EQUATION (USD)
$costs\_\_stdCost\_Norm \bullet costs\_\_repBtuh$

costs__stdCost_Norm = Normalized cost for a standard efficiency, standard GWP refrigerant, and non-connected unit ($/Btu/hr)
costs__repBtuh = The representative unit cooling capacity (Btu/hr)

Measure Case Material Cost ($/Unit)

The measure case material costs were retrieved from a webscraping analysis conducted in the first quarter 2023 from major online retailers. The analysis collected over 340 data points from retailers such as Home Depot, Lowes, Best Buy, Amazon, and Walmart. The dataset included factors such as system type, model number, brand, price, SEER, SACC, heating capacity (if applicable), and notes on additional features. A deeper review of individual products was completed to identify what refrigerant the product used and whether it had connected capabilities. The list of products was then reviewed for cost outliers and models that were not included in the Title 20 appliance database. Official Title 20 SACC and CEER values were added to the dataset for models that were included in the Title 20 appliance database.

Pricing for retail appliances, such as portable ACs and HPs, are expected to vary based on a number of factors, such as system type, cooling or heating capacity, brand, efficiency, and additional features, such as web connectivity. This analysis first calculated the normalized cost per SACC ($/Btu/hr) in order to review the costs across various capacities more evenly. The following additional data points were calculated for each product.

- Efficiency Tier: If the product was at least 5% more efficient than its Title 20 minimum, it was assigned to the efficient tier, otherwise it was in the standard tier.
- Low GWP: If the product used R-32 refrigerant, it was noted to as low GWP. If it used R-410A, it was noted as standard refrigerant. No other refrigerant were identified in the dataset and not all product data showed what refrigerant was used. If no refrigerant data was available, the unit was assumed to be in the standard refrigerant category.
- Connected Features: If the product was noted to have connected features, such as wi-fi connectivity, "smart" features, the ability to be controls from an app, or other related features, it was noted as connected. Otherwise, it was noted as not connected.

A hedonistic pricing approach was used in order to review the incremental cost impact of each feature. First, the average normalized cost for across various combinations of system type (AC/HP), efficiency (standard/efficient), low GWP refrigerant (Y/N), and connected features (Y/N) was conducted. Average values were calculated for datasets filtered by a single parameter, two parameters, three parameters, and all four parameters. When not relevant to the filtered parameters, all values were included. For example, if the filtered parameters were AC units with low GWP, both standard and efficient products, and connected and non-connected products were included in the average.

AC and HP efficiency and refrigerant are related features, therefore, this analysis considered them together when calculating averages for the measure case. For the measure offerings that include efficient ACs with low GWP refrigerant, the three parameter averages for AC, efficient products, and low GWP refrigerant were compared to the three parameter average for ACs, standard efficiency, and standard GWP refrigerant. The same analysis was completed for HP products. The percentage increase from the standard products to the efficient, low GWP products was found and used for calculating the measure case cost.

The costs to implement connected features for portable AC and HP are not expected to vary based on system type, efficiency, or refrigerant type. Therefore, the difference between the single parameter average of connected systems and non-connected systems was found and used to calculate the measure case cost for the connected offerings. The table below shows the percentages used for calculating the measure case costs. R2182

Costs - Calculation Inputs

MEASURE CASE EQUIPMENT	INCREMENTAL COST PERCENT - EFFICIENT CASE + LOW GWP (%)	INCREMENTAL COST PERCENT - CONNECTED (%)
Portable Air Conditioners	**4.92%**	**0.00%**
Portable Air Conditioners with Connected Controls	**4.92%**	**13.11%**
Portable Heat Pumps	**35.10%**	**0.00%**

MEASURE CASE EQUIPMENT	INCREMENTAL COST PERCENT - EFFICIENT CASE + LOW GWP (%)	INCREMENTAL COST PERCENT - CONNECTED (%)
Portable Heat Pumps with Connected Controls	**35.10%**	**13.11%**

These incremental percentage increases in cost were added to the base case material costs in order to calculate the material case costs.

Measure Case Material Cost

MEASURE CASE EQUIPMENT	EQUATION (USD)
Portable Air Conditioners	$costs\_mtlBase \bullet (1 + costs\_\_incEffGWP)$
Portable Air Conditioners with Connected Controls	$costs\_mtlBase \bullet (1 + costs\_\_incEffGWP + costs\_\_incConnected)$
Portable Heat Pumps	$costs\_mtlBase \bullet (1 + costs\_\_incEffGWP)$
Portable Heat Pumps with Connected Controls	$costs\_mtlBase \bullet (1 + costs\_\_incEffGWP + costs\_\_incConnected)$

costs_mtlBase = Base case material cost of portable AC or HP.
costs__incEffGWP = Increase in cost for an efficient, low GWP unit.
costs__incConnected = Increase in cost for a connected unit.

Base Case Labor Cost ($/Unit)

For all the base cases, labor costs are $0 because the portable AC/HPs are assumed to be self installed by homeowners.

Measure Case Labor Cost ($/Unit)

For all the measure cases, labor costs are $0 because the portable AC/HPs are assumed to be self installed by homeowners.

Net-to-Gross

The net-to-gross (NTG) ratio represents the portion of gross impacts that are determined to be directly attributed to a specific program intervention. This NTG is applicable to all energy efficiency measures that have been offered for less than two years and for which impact evaluation results are not available, as documented in the 2011 DEER Update Study conducted by Itron, Inc. R103 (page 15-4, Table 5-3)

Net-to-gross ratios are not required for POU measures. However, the following NTG ID is associated with this measure for potential future use in IOU programs.

Net to Gross Ratio

NET TO GROSS RATIO ID	NTG DESCRIPTION (TEXT)	NTG ELECTRIC (RATIO)	START DATE (TEXT)	EXPIRE DATE (TEXT)
All-Default<=2yrs	**Measures not covered by other NTG values and measure technology type has been available in marketplace for 2 years or less. This NTG value shall not be used for higher efficiency products of technology types that have been available in market place for more than 2 years.**	**0.7000**	**2019-01-01**	

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. R1270

Gross Savings Installation Adjustments - Default

GSIA ID	GSIA (RATIO) R1270
Def-GSIA	1.0000

Non-Energy Impacts

The installation of portable air conditioners and heat pumps results in various non-energy impacts (NEI). As part of this measure package, the NEIs related to refrigerant avoided costs (RACC), greenhouse gas (GHG) reduction, ASHRAE 55 thermal comfort for the LADWP territory were calculated.

REFRIGERANT AVOIDED COSTS

Resolution E-5152 requires IOU program administrators to report refrigerant leakage avoided costs (RLAC) for all energy efficiency measure claims for which the retrofit involves adding (not replacing) equipment that uses refrigerant, such as fuel substitution and electric resistance to heat pump measures, or measures for which low global warming potential (GWP) refrigerant measure benefits will be claimed, such as a change in the type or amount of refrigerant. R1503 E-5152 requires RLAC to be calculated from the CPUC refrigerant avoided cost calculator (RACC), the Deemed Measure RACC Workbook. R1613 Although this measure is for POUs only, these tools were used to calculate refrigerant impacts.

Since this measure requires low GWP refrigerants, the RACC analysis has been adjusted to accommodate different refrigerants used between the base and measure case equipment. To do this, four new technologies were added to the deemed RACC workbook: a portable AC with standard refrigerant, a portable AC with low GWP refrigerant, a portable HP with standard refrigerant, and a portable HP with low GWP refrigerant. The rows were added to the Refrig Type Defaults tab in the RACC to create the new equipment: R2185

Refrigerant Avoided Costs Calculator Inputs

EQUIPMENT TYPE	CASE	REFRIGERANT TYPE	REFRIGERANT CHARGE (LBS / UNIT)	LEAKAGE LOOKUP KEY	ANNUAL LEAKGE RATE
Portable Air Conditioner - Standard Refrigerant	Std/Pre	R-410A	1.54	Portable AC	1.0%
Portable Air Conditioner - Low GWP Refrigerant	Msr	HFC-32	1.54	Portable AC	1.0%
Portable Heat Pump - Standard Refrigerant	Std/Pre	R-410A	1.684	Portable AC	1.0%

EQUIPMENT TYPE	CASE	REFRIGERANT TYPE	REFRIGERANT CHARGE (LBS / UNIT)	LEAKAGE LOOKUP KEY	ANNUAL LEAKGE RATE
Portable Heat Pump - Low GWP Refrigerant	Msr	HFC-32	1.684	Portable AC	1.0%

The inputs for portable AC refrigerant charge come from the Refrigerant Leakage tab. No refrigerant charge was available for portable HP specifically, so the ratio of increased refrigerant change between a residential central HP and AC was used to increase the refrigerant charge for the HP offerings. Similarly, the leakage lookup table includes values for portable ACs but not HPs. This analysis assumed that both equipment have similar leakage rates.

Using the new equipment added to the RACC workbook, the RLAC for this measure were calculated with version 1.3-Rev4 of the Deemed Measure RACC Workbook. R2185

Refrigerant Avoided Cost Calculations Outputs

MEASURE CASE EQUIPMENT	MEASURE APPLICATION TYPE	REFRIGERANT NPV COSTS – PRE-EXISTING (USD)	REFRIGERANT NPV COSTS - STANDARD BASELINE (USD)	REFRIGERANT NPV COSTS - MEASURE (USD)	UNIT REFRIGERANT COST (USD)	UNIT REFRIGERANT BENEFITS (USD)
Portable Air Conditioners	NC	**$0.00**	**$46.57**	**$15.06**	**$0.00**	**$31.51**
Portable Air Conditioners	NR	**$0.00**	**$46.57**	**$15.06**	**$0.00**	**$31.51**
Portable Air Conditioners with Connected Controls	NC	**$0.00**	**$46.57**	**$15.06**	**$0.00**	**$31.51**
Portable Air Conditioners with Connected Controls	NR	**$0.00**	**$46.57**	**$15.06**	**$0.00**	**$31.51**
Portable Heat Pumps	NC	**$0.00**	**$50.94**	**$16.47**	**$0.00**	**$34.47**
Portable Heat Pumps	NR	**$0.00**	**$50.94**	**$16.47**	**$0.00**	**$34.47**
Portable Heat Pumps with Connected Controls	NC	**$0.00**	**$50.94**	**$16.47**	**$0.00**	**$34.47**

MEASURE CASE EQUIPMENT	MEASURE APPLICATION TYPE	REFRIGERANT NPV COSTS – PRE-EXISTING (USD)	REFRIGERANT NPV COSTS - STANDARD BASELINE (USD)	REFRIGERANT NPV COSTS - MEASURE (USD)	UNIT REFRIGERANT COST (USD)	UNIT REFRIGERANT BENEFITS (USD)
Portable Heat Pumps with Connected Controls	NR	**$0.00**	**$50.94**	**$16.47**	**$0.00**	**$34.47**

GREENHOUSE GAS IMPACTS

LADWP has developed projections for carbon emissions intensities (ton CO2e /kWh) for the years 2023 through 2034. Based on these emissions values, the total lifetime GHG reductions and average annual GHG reduction over the measure lifetime were calculated for each offering, building type, and climate zone in the LADWP region. To do this, the annual electric energy savings was multiplied by the carbon intensity per year and summed over the full EUL of the offerings. Since the GHG emissions projections are only available until 2034, it was conservatively assumed that all following years used the same intensities as 2034. Furthermore, the GHG emissions associated with natural gas impacts were also summed to find the total GHG impacts for the offering. The values in the table below represent the average across each building type and for LADWP climate zones. R2226 R2227 R2184

Lifetime and Annual Carbon Emissions Per Measure

OFFERING ID	MEASURE DESCRIPTION	BASE CASE DESCRIPTION	AVERAGE LIFETIME GHG REDUCTIONS PER UNIT (METRIC TON CO2E)	AVERAGE ANNUAL GHG REDUCTIONS OVER LIFETIME PER UNIT (METRIC TON CO2E/YR)
A	Efficient portable air conditioner, CEER 5% greater than T20 standard	Standard portable air conditioner, T20 CEER	0.064	0.007
B	Efficient portable air conditioner with connected controls, CEER 5% greater than T20 standard	Standard portable air conditioner, T20 CEER	0.064	0.007
C	Efficient portable heat pump, CEER 5% greater than T20 standard	Standard portable heat pump, T20 CEER	0.043	0.005
D	Efficient portable heat pump with connected controls, CEER 5% greater than T20 standard	Standard portable heat pump, T20 CEER	0.043	0.005

ASHRAE 55 COMFORT ANALYSIS

ASHRAE 55-2020 Thermal Environmental Conditions for Human Occupancy provides a methodology and analysis tools to review the impacts of conditioned spaces on human thermal comfort. ASHRAE 55-2020 includes two primary models to estimate comfort; the predicted mean vote (PMV) and the predicted percentage dissatisfied (PPD) models. This analysis uses the Predicted Mean Vote (PMV) model, which is "an index that predicts the mean value of the thermal sensation votes (self-reported perceptions) of a large group of persons on a sensation scale expressed from –3 to +3 corresponding to the categories "cold," "cool," "slightly cool," "neutral," "slightly warm," "warm," and "hot." R2153

ASHRAE 55-2020 uses a threshold of +/- 0.5 as the indices where an occupant is considered comfortable. For existing buildings, the International Organization for Standardization (ISO), in their standard *ISO 7730:2005 Ergonomics of the thermal environment,* uses +/- 0.7 as the threshold for comfort. R2154 However, one of the intents of implementing this measure is to reduce prolonged exposure to extreme heat conditions which can cause severe health issues. To review the impact of this measure on excessive in-home heat exposure, this analysis expanded the threshold use PMV values of +/- 2.0. This range reflects the hours of extreme temperatures that can lead to harm with prolonged exposure. The Portable AC analysis only analyzed the extreme warm temperatures, while the Portable HP analysis analyzed both extreme warm and cold temperatures.

ASHRAE Thermal Comfort Index

ASHRAE 55-2020 PMV INDEX	SENSATION DESCRIPTION
-3	Cold
-2	Cool
-1	Slightly cool
-0.7	Comfortable
0	Neutral (Comfortable)
+0.7	Comfortable
+1	Slightly warm
+2	Warm
+3	Hot

The environmental conditions that affect the PMV index include, dry bulb air temperature, mean radiant temperature (MBT), air speed, relative humidity, metabolic rate, and clothing level. To review the changes in thermal comfort modelled in the EnergyPlus models, the hourly values for representative zones were exported for dry bulb temperature, mean radiant temperature, and relative humidity. For single family and mobile homes, all conditioned zones were exported. Critical errors in the models prevented the modeling of the no heating/cooling baseline the SFm building type models in CZ01. Since multifamily models include dozens of zones, a sampling of 8 zones on the south and west facing sides and corners of the home were exported as these were assumed to represent

the warmest zones. In addition to the values exported from EnergyPlus, the following variables were held constant in the analysis.
R2226 R2227

Thermal Comfort Calculator Inputs

PARAMETER	VALUE	NOTES
Air speed	0.1 m/s	Typical indoor air speed
Metabolic Rate	1.0 met	Activity level: Seated, quiet (Table 5-1)

Clothing (clo) values are assumed to vary throughout the year as the seasons change. Therefore, the following clo values were used in the analysis for the months associated with the different seasons. The summer months were selected to align with LADWP billing high season summer months. The different season lengths were select to be equal parts of the year.

Thermal Comfort Calculator Clothing Insulation Inputs

CLOTHING ASSUMED	CLO VALUE	ASSUMED MONTHS
Typical summer indoor clothing	0.50	Summer: June through September
Typical winter indoor clothing	1.00	Winter: December through March
Trousers, long-sleeve shirt	0.61	Spring: April through May Fall: October through November

The Center for the Built Environment (CBE) at the University of California, Berkley has developed the CBE Thermal Comfort Tool (https://comfort.cbe.berkeley.edu/). It is an online tool which uses the algorithms provided in *ASHRAE 55-2020* to calculate thermal comfort values using a variety of methods and inputs. CBE also provides a python script (thermalcomfort.py) that that can be used for bulk processing efforts. The PMV model python script was run with the previously mentioned input variables to return hourly comfort values for each base and measure case model.

Additionally, three new weather files were run for the LADWP territory. These weather files were developed by the University of California, Los Angles (UCLA) as part of LADWP's LA100 initiative to simulate extreme weather events in the year 2035. These weather files represented Los Angeles International Airport (LAX), Downtown Los Angeles/University of Southern California (USC), and the Van Nuys Airport, which correspond to climate zones 6, 8, and 9, respectively.

The comfort analysis for the baseline unedited DEER prototype models showed varying levels of uncomfortable hours. Therefore, a percentage change of uncomfortable hours between the base case and measure case was conducted instead of a review of absolute hours changed due to the implementation of the measure. AC equipment hours were compared for only half of the year estimated as the cooling season, while HP equipment was compared for the whole year. For the sake of this analysis, the connected equipment was assumed to operate the same as the non-connected equipment and is not shown separately.

The table below shows the impacts of the comfort analysis averaged across all building types and LADWP climate zones. The rightmost column represents the values for the extreme heat weather files only. R2186 R2226 R2227 The findings show a reduction in uncomfortable hours of 4.05% when AC equipment is installed where there was originally no cooling, which accounts for roughly 178 hours during the cooling season. This corresponds to roughly 30 days if the unit is only run during the 6 hottest hours of the day. They also show a reduction in uncomfortable hours of 2.83% when HPs are installed where there was no cooling or heating, which accounts for roughly 248 hours annually, or 41 days of the unit operating 6 hours daily. Higher reductions are seen when using the extreme weather files, estimated at 6.23% and 274 (46 days) hours for ACs and 4.10% and 359 hours (60 days) for HPs using similar daily assumptions.

Reduction in Uncomfortable Hours Per Measure

OFFERING ID	MAT	MEASURE DESCRIPTION	BASE CASE DESCRIPTION	PERCENT CHANGE IN UNCOMFORTABLE HOURS (%) - CZ2022 WEATHER	PERCENT CHANGE IN UNCOMFORTABLE HOURS (%) - LA100 2035 WEATHER
A/B	NR	Efficient Portable Air Conditioners	Standard Portable Air Conditioners	0.00%	0.00%
A/B	NC	Efficient Portable Air Conditioners	Home with no cooling	-4.05%	-6.23%
C/D	NR	Efficient Portable Heat Pump	Standard Portable Heat Pump	0.00%	0.00%
C/D	NC	Efficient Portable Heat Pump	Home with no cooling or heating	-2.83%	-4.10%

DEER Differences Analysis

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

DEER Difference Summary

DEER ITEM	COMMENT
Modified DEER methodology	No
Scaled DEER measure	No
DEER Base Case	No
DEER Measure Case	No
DEER Building Types	Yes
DEER Operating Hours	Yes
DEER eQUEST Prototypes	No
DEER Version	N/A
Reason for Deviation from DEER	DEER does not have measures for portable air conditioners and heat pumps.
DEER Measure IDs Used	N/A

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R2154 International Organization for Standards. (ISO). 2005. *Ergonomics of the thermal environment - Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria.* ISO 7730:2005.

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