

**Work Paper PGECO HVC128
Unitary Air-Cooled Commercial Air
Conditioners ≥ 65 kBtu/h
Revision #9**

Pacific Gas & Electric Company
Customer Energy Solutions

**Unitary Air-Cooled
Commercial Air
Conditioners ≥ 65 kBtu/h**

Measure Codes: HV340, HV341, HV342, HV343, HV344, HV345, HV346, HV347, HV348,
HV349, HV350, HV351, HV352

July 1, 2017

AT-A-GLANCE SUMMARY

Measure Codes	See list of all measure/solution codes within the report
Measure Description	HVAC Program for equipment replacement of commercial, unitary air-cooled air conditioners greater than or equal to 65,000 Btu/h.
Base Case Description	Source: Title 20 and Title 24 Unitary air-cooled air conditioners greater than 65,000 Btu/h that meets Title 20 and Title 24 efficiency standards.
Units	kW/ton, kWh/ton, therms/ton of cooling
Energy Savings	Refer to Excel Calculation Attachment
Full Measure Cost (\$/unit)	From distributor survey refer to excel attachment in the appendix
Incremental Measure Cost (\$/unit)	From distributor survey refer to excel attachment in the appendix
Effective Useful Life	Source: DEER 2016 15 years, EUL ID "HVAC-airAC" – Air Conditioners (Air-Cool, Split and Unitary)
Measure Installation Type	Replace on Burnout (ROB) and New Construction (NC) – All IOUs
Net-to-Gross Ratio	Source: DEER2016 NTG = 0.75, "NonRes-sAll-mHVAC-DX-up" for Nonresidential Package HVAC Equipment: deemed; upstream NTG = 0.60, "Com-Default>2yrs" for all other EEMs with no evaluated NTGR; existing EEm in programs with same delivery mechanism for more than 2 years
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
Superseded Work Paper	2006	PG&E and Energy Solutions	2006 HVAC unit savings V26.doc
Revision 0	04/11/08	Jenny Roecks (PG&E)	Unitary Commercial Air Conditioners and Heat Pumps greater than or equal to 65 kBtuh PGECOHC128 R0.doc
Revision 1	12/15/09	Megan Johnson (Energy Solutions) and Jenny Roecks (PG&E)	Unitary Commercial Air Conditioners and Heat Pumps greater than or equal to 65 kBtuh PGECOHC128 R1.doc
Revision 2	2/22/10	Megan Johnson (Energy Solutions) and Jenny Roecks (PG&E)	Unitary Commercial Air Conditioners and Heat Pumps greater than or equal to 65 kBtuh PGECOHC128 R2.doc
Revision 3	6/18/12	Jun Furuta (Energy Solutions) and Chris Li (PG&E)	<ul style="list-style-type: none"> Revised document to use new PG&E work paper template and sections (1.1) Added new measures and tiers and changed the part load performance rating from IPLV to IEER (1.4) Added gas savings due to interactive effects (2.0) Revised calculation methods to use weighted average of both full and part load performance rating savings estimates (3.1) Revised load shapes to those available in DEER2011
Revision 3	8/28/12	Christopher Li (PG&E)	Update workpaper to include OTR definition.
Revision 4	06/17/14	Yin Yin Wu, P.E. (BASE Energy, Inc.) Chris Li (PG&E)	<ul style="list-style-type: none"> Six (6) new Tiers are added Baseline efficiencies are updated per 2013 Title 24, effective July 1, 2014 Savings are updated per 2014 DEER savings outputs in READI v.2.0.1 and 2014 DEER models in MASControl V3.0019
Revision 5	1/29/2015	Chris Li (PG&E)	Savings are updated based on the 2015 DEER savings outputs in READI v.2.1.0.
Revision 6	10/13/2015	Andres Fergadiotti/SCE	<ul style="list-style-type: none"> Updated Workpaper templates Confirmed that there are no variations on measure impacts between READI v2.1.0 and v2.3.0 (included DEER/READI impacts and Measure Definitions) Eliminated expired Building Types including Agricultural, Food Store, Health/Medical – Clinic, Industrial, Misc – Commercial, and Transportation – Communication - Utilities Updated tier matrix per DEER2016 guidance excluding extrapolation on lower and higher tiers including HV040/AC-33251; HA24/AC-89845; HV041/AC-64298; HV042/AC-86849; HA25/AC-84788; HA39/AC-75859 Updated cost documentation per DEER2016- Costs_PkgHVAC-Boilers_8-31-2015-DRAFT workbook

			<ul style="list-style-type: none"> • NTG, EUL, GSI as applicable
Revision 7	7/8/2016	Henry Liu / PG&E	<ul style="list-style-type: none"> • HA24 135-239kBtu/h 13.0 EER or 15.2 IEER to claim savings, but it uses the UES from HA23 135-239kBtu/h 12.5 EER or 13.6 IEER • The cost used for HA24 was from WO17 but the EER limitation is 12.6, more work will be done to find accurate cost later this year when the work paper is updated for DEER2017
Revision 8	12/6/2016	Henry Liu / PG&E	<ul style="list-style-type: none"> • Updated savings values for DEER2017 • Changed the structure of the program from using "or" for efficiency ratings to "and" requirement for all measures • Updated costs based on distributor surveys • Changed to COM building types only • Added new construction • New measure codes with tiers directly from DEER2017: HV340/AC-18662, HV341/AC-18689, HV342/AC-18664, HV343/ AC-18666, HV344/ AC-18667, HV345/AC-18668, HV346/AC-18657, HV347/ AC-18658, HV348/ AC-18659, HV349/ AC-18660, HV350/ AC-18671, HV351/ AC-18672, HV352/AC-18673, AC-18665, AC-18670, AC-18661, AC-18674 • Changed the ToCode measure channel to downstream used by SCE • New NTG for downstream channel
Revision 9	11/10/2017	Danielle Dragon, PE, CEM, CDSM (PG&E)	<ul style="list-style-type: none"> • Updated savings values for DEER2017 (effective date 7/1/2017) • Remove Early Retirement (SCE no longer supports) • Remove labor cost (due to removal of Early Retirement) • Added midstream • Removed heat pumps from most of word document (as it already wasn't included in Revision 8 measure savings spreadsheet). Large heat pump measure has not been updated/compliant in DEER.

COMMISSION STAFF AND CAL TF COMMENTS

Rev	Party	Submittal Date	Comment Date	Comments	WP Developer Response
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				•	•

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

SECTION 1. GENERAL MEASURE & BASELINE DATA

1.1 MEASURE DESCRIPTION & BACKGROUND

This work paper documents the rationale for the savings methodologies and assumptions for installing high efficiency unitary air-cooled air conditioning (A/C) units 65 kBtu/h (5.4 tons) and larger in non-residential installations.

Base, Standard, and Measure Cases

Case	Description of Typical Scenario
Measure	High Efficient EER/IEER Rated Packaged/Split Air Conditioner, 65kBtu/h or larger
Existing Condition	Standard Efficient [ROB] EER/IEER Rated Packaged/Split Air Conditioner, 65kBtu/h or larger
Code/Standard	Standard Efficient EER/IEER Rated Packaged/Split Air Conditioner, 65kBtu/h or larger
Industry Standard Practice	N/A

Measure and Codes table below includes measures that have been removed as part of ED's DEER2016 guidance allowing interpolation between measures using either EER ratings or appropriate IEER ratings, but excluding extrapolation.

Table 1: Measures and Codes

Measure Codes					Measure Name
SCG	SDG&E	SCE	PG&E	Tier	
Greater than or equal to 5.4 tons (65,000 Btu/h) but less than 11.3 tons (135,000 Btu/h)					
		AC-18657	HV346	1	65 - 134 KBTU/H, EER = 11.5 AND MIN IEER = 13 Air Source Unitary Air Conditioner DX Equipment
		AC-18658	HV347	2	65 - 134 KBTU/H, EER = 12 AND MIN IEER = 13.5 Air Source Unitary Air Conditioner DX Equipment
		AC-18659	HV348	3	65 - 134 KBTU/H, EER = 12.5 AND MIN IEER = 14 Air Source Unitary Air Conditioner DX Equipment
		AC-18660	HV349	4	65 - 134 KBTU/H, EER = 13 AND MIN IEER = 15 Air Source Unitary Air Conditioner DX Equipment
		AC-18661	N/A	N/A	65 - 134 KBTU/H – To Code Savings Portion Air Source Unitary Air Conditioner DX Equipment
Greater than or equal to 11.3 tons (135,000 Btu/h) but less than 20 tons (240,000 Btu/h)					
		AC-18662	HV340	1	135 - 240 KBTU/H, EER = 11.5 AND MIN IEER = 13 Air Source Unitary Air Conditioner DX Equipment
		AC-18689	HV341	2	135 - 240 KBTU/H, EER = 12 AND MIN IEER = 13.5 Air Source Unitary Air Conditioner DX Equipment
		AC-18664	HV342	3	135 - 240 KBTU/H, EER = 12.5 AND MIN IEER = 14 Air Source Unitary Air Conditioner DX Equipment
		AC-18665	N/A	N/A	135 - 240 KBTU/H - To Code Savings Portion Air Source Unitary Air Conditioner DX Equipment

Greater than or equal to 20 tons (240,000 Btu/h) but less than 63.3 tons (760,000 Btu/h)					
		AC-18666	HV343	1	240 - 760 KBTU/H, EER = 10.8 AND MIN IEER = 12.2 Air Source Unitary Air Conditioner DX Equipment
		AC-18667	HV344	2	240 - 760 KBTU/H, EER = 11.5 AND MIN IEER = 12.7 Air Source Unitary Air Conditioner DX Equipment
		AC-18668	HV345	3	240 - 760 KBTU/H, EER = 12.5 AND MIN IEER = 15.5 Air Source Unitary Air Conditioner DX Equipment
		AC-18670	N/A	N/A	240 - 760 KBTU/H – To Code Savings Portion Air Source Unitary Air Conditioner DX Equipment
Greater than or equal to 63.3 tons (760,000 Btu/h)					
		AC-18671	HV350	1	760 - KBTU/H, EER = 10.2 AND MIN IEER = 11.6 Air Source Unitary Air Conditioner DX Equipment
		AC-18672	HV351	2	760 - KBTU/H, EER = 11 AND MIN IEER = 12.3 Air Source Unitary Air Conditioner DX Equipment
		AC-18673	HV352	3	760 - KBTU/H, EER = 12 AND MIN IEER = 13.8 Air Source Unitary Air Conditioner DX Equipment
		AC-18674	N/A	N/A	760 - KBTU/H - To Code Savings Portion Air Source Unitary Air Conditioner DX Equipment

Catalog Description

The measures presented on this workpaper are promoted under the midstream and upstream HVAC program.

Program Restrictions and Guidelines

The rebate is midstream and upstream provided to the distributor at the time of sale upon receipt of sales data. This is not a direct install program.

Measure Requirements

- All unitary DX equipment is eligible. Replacement must be like-for-like.
- Measure case equipment must have cooling capacity (Btu/h) within 5% of existing equipment OR contractor must provide a load calculation verifying that the new unit is sized correctly for the load.
- Central systems and DHW systems are not eligible.
- Package terminal AC units, which are units manufactured for installation through a wall or window and are usually less than or equal to 2 tons, are not eligible.
- The current EER and IEER requirements and tiers are shown in Table 1.
- Installed address must be located in PG&E's or SCE's service territory.

Market Applicability

Single-package air conditioners are very common in commercial construction. The market share for split systems is approximately 1:20 split system versus single-package in the commercial market sector.

Air-cooled single-package and split-system A/C units greater than or equal to 5.4 tons (65,000 Btu/h) and less than 11.3 tons (135,000 Btu/h) are used frequently on a variety of facilities types: convenience markets, fast-food stores, office complexes, and strip malls. The majority of this equipment will be single-package units. Split-system air conditioners are less common in commercial construction than in residential construction.

Air-cooled single-package and split-system A/C units greater than or equal to 11.3 tons are commonly used to condition larger commercial open spaces as would be found in large chain outlet stores. The measures addressing this size of A/C units are typically applicable to specific Standard Industrial Classifications (SICs) in the commercial market and the industrial sector where large spaces are conditioned.

1.2 TECHNICAL DESCRIPTION

A single-package A/C unit consists of a single package (or cabinet housing) that contains a condensing unit, a compressor, and an indoor fan/coil. Single-package units are typically installed on the roof of the building and will sit on a "roof-curb" or supporting beams. Down-flow units have the benefit of concealed ducting, thus minimizing the chances of water leaking through a roof penetration. An additional benefit of package units is that there is no need for field-installed refrigerant piping, thus minimizing labor costs and the possibility of contaminating the system with dirt, metal, oxides or non-condensing gases.

A split system consists of two major parts in separate housings: a remote condensing unit, and an indoor fan/coil. The two system components are connected by a set of refrigerant lines. Where the heating system is gas-fired, the fan/coil will include a furnace section. 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.

Model numbers are used to determine equipment efficiencies for package systems. Equipment efficiencies for split systems will be based on a combination of the condenser and evaporator model numbers provided by the distributors. Efficiencies will then be verified by the use of the ARI/CEE database or manufacturers specification sheets. Field inspections will be performed to verify the condenser/unit model number for quality assurance purposes.

Because of the large number of evaporator/condenser combinations available for split systems (several thousand combinations) some averages and/or minimum efficiencies may be used for certain groups of equipment.

EER and IEER

Air conditioners greater than 65,000 Btu/h have two different measures of energy efficiency: 1) Energy Efficiency Ratio (EER) and 2) Integrated Energy Efficiency Ratio (IEER). EER is the measure of energy efficiency corresponding to Peak loading (kW), and IEER corresponds to a weighted average of ratings at different loads considering part load performance. Another earlier metric for part load performance was

the Integrated Part Load Value (IPLV), which is no longer used by the HVAC industry as of January 1, 2010.

The 2004-06 Upstream HVAC program required equipment to meet both EER and IPLV standards. This requirement did not allow high IPLV (that result in high kWh savings) units to qualify and sent the wrong market signal to the marketplace (manufacturers and distributors). Some manufacturers specifically design for higher IPLVs because this efficiency more closely predicts seasonal consumption and energy savings. The 2006-08 Program accepted units that met either the EER minimum efficiency "or" the IPLV minimum efficiency, resulting in more high efficiency units installed in PG&E and SCE territories. Manufacturers have continued to design new equipment to achieve increasingly higher part load (now IEER) values. Analysis of equipment submitted to the PG&E and SCE Upstream HVAC Programs from 2010 through 2012 shows the average EER for unitary equipment greater than 5.4 tons has gone down over time while the average IEER has gone up in the same period. See Appendix A for additional supporting documentation.

The 2017 program will require both the EER and IEER be met before it qualifies for the program.

1.3 INSTALLATION TYPES AND DELIVERY MECHANISMS

The program delivery mechanism is **Upstream Programs – Up-Stream Incentive** and **Mid-Stream Programs – Midstream Incentive**.

The application types are:

Replace-on-Burnout (ROB) and NEW/NC

Incentives are offered for installation of air-conditioning equipment that is more efficient than what is required by code. High-efficiency heat pumps are not considered in this work paper because they comprise a very small percentage of the market. Incentives are provided to the distributors at the time of sale upon receipt of sales data.

The program delivery mechanism is Up-Stream and Mid-Stream Incentive, Buy Down Programs, which will give financial incentive to HVAC sales distribution channels, such as manufacturers and distributors (Upstream and Midstream Market Actor), in order to stock and upsell premium high efficiency equipment.

Premium efficiency equipment is significantly more efficient than the state and federal code baseline. The incentives are paid to the Upstream, Midstream, and Downstream Market Actors who may do what they deem best with the incentive. The program does not control or restrict the Market Actor's use of the funding.

Installation Type Descriptions

Installation Type	Savings		Life	
	1 st Baseline (BL)	2 nd BL	1 st BL	2 nd BL
Replace on Burnout (ROB)	Above Code or Standard	N/A	EUL	N/A
New Construction (NEW/NC)	Above Code or Standard	N/A	EUL	N/A
Retrofit or Early Replacement (RET/ER)	Above Customer Existing	Above Code or Standard	RUL	EUL-RUL
Retrofit First Baseline Only (REF)	Above Customer Existing	N/A	EUL	N/A
Retrofit Add-on (REA)	Above Customer Existing	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
Appliance Turn-in and Recycling	The program motivates customers, through financial incentives, to recycle appliances that are functional but inefficient. This prevents the continued use of those appliances, by both the current owner and potential future owners.
Audit - Information - Testing Services	The program performs a free assessment of a customer's facility and provides the customer with information and guidance on energy efficiency opportunities.
Financial Support	The program motivates customers, through financial incentives such as rebates or low interest loans, to implement energy efficient measures or projects.
Mid-Stream Programs	<i>See Mid-Stream Incentive in the Incentive Method Descriptions table.</i>
Partnership	The program implements projects through a partnership between the utility and an institutional, government, or community-based organization.
Up-Stream Programs	<i>See Up-Stream Incentive in the Incentive Method Descriptions table.</i>

Incentive Method Descriptions

Incentive Method	Description
Direct Install	The program implements energy efficiency measures for qualifying customers, at no cost to the customer.
Down-Stream Incentive	The customer installs qualifying energy efficient equipment and submits an incentive application to the utility program. Upon application approval, the utility program pays an incentive to the customer. Such an incentive may be deemed or customized.
Exchange - Replacement	The utility program holds events where customers can trade functional equipment for similar but more energy efficient equipment, free of charge.
Giveaway	The program provides customers with energy efficiency equipment or services for free.
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.
On-bill Finance – Loan (OBF)	The program offers financing for the cost of an efficient measure as part of the utility bill. This can be an add-on option to an existing program or can serve as an organizing principle for its own program.
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.

1.4 MEASURE PARAMETERS

1.4.1 DEER Data

The program uses full load EER and part load IEER ratings to qualify the equipment, so a weighted average of EER based DEER data and IEER based calculated demand and energy savings were used for each measure. This is described in greater detail later in the report in Section 2.

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	No
DEER Version	DEER 2017, READI v2.4.7
Reason for Deviation from DEER	Measure impacts taken directly from DEER/READI.
DEER Measure IDs Used	See Section 2 - READI data used

DEER2016 Packaged and Split Air Conditioner Update

IEER Rating Update

The IEER values published in the Technology Definitions for the DEER2016 Update were calculated based on typical expected operation. These values did not always correspond with the rated IEER values published by the equipment manufacturers. For the DEER2017 update, manufacturer rated IEER values were collected and applied to the Technology Definitions.

Impact of fan control on IEER

The type of fan control installed on a system affects the IEER rating. Most manufacturers now provide a description of the fan control that was used in the development of each IEER value. For some units where different fan control options are available, multiple IEER values are listed. In the IEER versus EER data that was collected for the DEER2017 update, the fan control strategy was either constant volume or two-speed. For each unit size range, relationships were established between rated IEER and rated EER for both of these fan control strategies. Both values are now listed in the Measure and Technology tables.

Program Claims

When program claims are made the EER and IEER rating will determine the tier the equipment will qualify for. The 2016 DEER database is not applicable to 3-speed or variable speed DX systems.

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
NonRes-sAll-mHVAC-DX-up	All package and split system AC & HP replacements	Com	Any	PreRebUp	0.75

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 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-airAC	Air Conditioners (air-cooled, split and unitary)	Com	HVAC	15	5

1.4.2 Codes and Standards Analysis

Code Summary

Code	Reference	Effective Dates
Title 20 (2016)	Section 1605.1(c)(1)	January 1, 2016
Title 24 (2016)	Section 110.2(a)	January 1, 2017

Title 20 (2016)

These measures fall under Title 20 of the California Energy Regulations. The efficiency requirements in Title 20 apply for units less than 63.3 tons (760,000 Btu/hr) and the effective date is July 1, 2014. Under the 2014 Title 20 regulation, the following is required by Section 1605.1(c) (1): "Central Air Conditioners Other than Water-Source Heat Pumps below 240,000 Btu/hr. The EER, SEER, COP, and HSPF, as applicable, of all central air conditioners shall be not less than the applicable values shown in Tables C-2, C-3, C-4, C-5, and C-6." The efficiency requirements for air-cooled air conditioning units over 5.4 tons (65,000 Btu/hr) are identified in Table C-4 (more than 5.4 tons or 65,000 Btu/h) of Title 20, and shown below:

Title 20 Standards for Large Unitary Equipment

Title 20 Std. Description	Base or Measure Case	Value	Units	Code Source or Reference
Air-cooled unitary air conditioners ≥ 65,000 and < 135,000 Btu/h	Base	10.8	EER	Table C-4, Title 20, 2016
Air-cooled unitary heat pumps in cooling mode ≥ 65,000 and < 135,000 Btu/h	Base	11.0	EER	
Air-cooled unitary air conditioners ≥ 135,000 and < 240,000 Btu/h	Base	10.8	EER	
Air-cooled unitary heat pumps in cooling mode ≥ 135,000 and < 240,000 Btu/h	Base	10.4	EER	
Air-cooled unitary air conditioners ≥ 240,000 and < 760,000 Btu/h	Base	9.8	EER	
Air-cooled unitary heat pumps in cooling mode ≥ 240,000 and < 760,000 Btu/h	Base	9.3	EER	

Title 24 (2016)

These measures fall under Title 24 of the California Energy Regulations, which sets minimum ratings using both EER and IEER. Table below shows the minimum requirements for each standard.

The following is required by Section 110.2(a): "All space conditioning equipment installed in a nonresidential building subject to these regulations must be certified as meeting certain minimum efficiency and control requirements. These requirements are contained in §110.2 of the Standards. Minimum efficiencies vary based on the type and capacity of the equipment." The efficiency requirements for electrically operated unitary air conditioners are identified in Table 110.2-A in Title 24.

Title 24 Standards for Large Unitary Equipment

Title 24 Std. Description	Base or Measure Case	Value*	Units	Code Source or Reference
Air-cooled unitary air conditioners ≥ 65,000 and < 135,000 Btu/h	Base	11.0 12.7	EER IEER	Table 4-1 Title 24, 2016
Air-cooled unitary air conditioners ≥ 135,000 and < 240,000 Btu/h	Base	10.8 12.2	EER IEER	
Air-cooled unitary air conditioners ≥ 240,000 and < 760,000 Btu/h	Base	9.8 11.4	EER IEER	
Air-cooled unitary air conditioners ≥ 760,000 Btu/h	Base	9.5 11.0	EER IEER	
Air-cooled unitary heat pumps in cooling mode ≥ 65,000 and < 135,000 Btu/h	Base	10.8 12.0	EER IEER	Table 4-2 Title 24, 2016
Air-cooled unitary heat pumps in cooling mode ≥ 135,000 and < 240,000 Btu/h	Base	10.4 11.4	EER IEER	
Air-cooled unitary heat pumps in cooling mode ≥ 240,000	Base	9.3 10.4	EER IEER	

* The base case is for equipment with a gas furnace heating section.

Federal Standards

The California standards exceed Federal requirements.

1.5 EM&V, MARKET POTENTIAL, AND OTHER STUDIES – BASE CASE AND MEASURE CASE INFORMATION

There were no M&V or other studies which were referenced for these measures.

1.5.1 Assumptions and Calculations from other sources—Base and Measure Cases

The savings were downloaded from DEER2017 directly.

Energy Savings Assumption (ΔW , ΔTherms):

Electric kW savings were downloaded from DEER2017 READI tool (v2.4.7).

Hours of Operation:

The hours of operation are not applicable for this type of measure. The savings values used were downloaded from DEER2017 directly. All measures listed on this work paper have a wide range of equivalent full load hours (EFLH) where it varies depending on the climate zones, building types, and building vintages. Since DEER data was used for the calculation of energy impacts, the hours of operation are embedded in those values. DEER simulations calculate the values based on the use of building vintages for each climate zone that are then weighted by the climate zone specific distribution of the vintages to get values for Existing (Ex).

Base Case Costs and Measure Case Costs:

The Base Case, Measure Case, and Incremental Costs were surveys on distributors based on 2016 proposed efficiency tiers and interpolated to DEER 2017 tiers. There is attachment #2 in the appendix to show the tiers and findings.

1.6 DATA QUALITY AND FUTURE DATA NEEDS

Measure impacts in current version of DEER/READI does not support high performance systems with tier levels generally above 14.8 IEER. Further, DEER/READI impacts limit program claims on high performance systems including those that comply with DOE's RTU Challenge Program with efficiencies starting at 18.0 IEER.

SECTION 2. CALCULATION METHODOLOGY

Electric Energy Savings

kW and kWh for the base case and the measure case units were downloaded from DEER2017 (READI, v.2.4.7).

The electric energy savings were downloaded from DEER2017 of above code/standard savings. The following table indicates which measures are taken directly from or created with the DEER READI tool.

PG&E Measure Code	SCE Solution Code	Measure Name	Impact ID
HV346	AC-18657	65 - 134 KBTU/H, EER = 11.5 AND MIN IEER = 13 Air Source Unitary Air Conditioner DX Equipment	NE-HVAC-airAC-SpltPkg-65to134kBtuh-11p5eer-wPreEcono
HV347	AC-18658	65 - 134 KBTU/H, EER = 12 AND MIN IEER = 13.5 Air Source Unitary Air Conditioner DX Equipment	NE-HVAC-airAC-SpltPkg-65to134kBtuh-12p0eer-wPreEcono
HV348	AC-18659	65 - 134 KBTU/H, EER = 12.5 AND MIN IEER = 14 Air Source Unitary Air Conditioner DX Equipment	NE-HVAC-airAC-SpltPkg-65to134kBtuh-12p5eer-wPreEcono
HV349	AC-18660	65 - 134 KBTU/H, EER = 13 AND MIN IEER = 15 Air Source Unitary Air Conditioner DX Equipment	NE-HVAC-airAC-SpltPkg-65to134kBtuh-13p0eer-wPreEcono
N/A	AC-18661	65 - 134 KBTU/H – To Code Savings Portion Air Source Unitary Air Conditioner DX Equipment	NE-HVAC-airAC-SpltPkg-65to134kBtuh-11p5eer-wPreEcono
HV340	AC-18662	135 - 240 KBTU/H, EER = 11.5 AND MIN IEER = 13 Air Source Unitary Air Conditioner DX Equipment	NE-HVAC-airAC-SpltPkg-135to239kBtuh-11p5eer
HV341	AC-18689	135 - 240 KBTU/H, EER = 12 AND MIN IEER = 13.5 Air Source Unitary Air Conditioner DX Equipment	NE-HVAC-airAC-SpltPkg-135to239kBtuh-12p0eer
HV342	AC-18664	135 - 240 KBTU/H, EER = 12.5 AND MIN IEER = 14 Air Source Unitary Air Conditioner DX Equipment	NE-HVAC-airAC-SpltPkg-135to239kBtuh-12p5eer
N/A	AC-18665	135 - 240 KBTU/H - To Code Savings Portion Air Source Unitary Air Conditioner DX Equipment	NE-HVAC-airAC-SpltPkg-135to239kBtuh-11p5eer
HV343	AC-18666	240 - 760 KBTU/H, EER = 10.8 AND MIN IEER = 12.2 Air Source Unitary Air Conditioner DX Equipment	NE-HVAC-airAC-SpltPkg-240to759kBtuh-10p8eer
HV344	AC-18667	240 - 760 KBTU/H, EER = 11.5 AND MIN IEER = 12.7 Air Source Unitary Air Conditioner DX Equipment	NE-HVAC-airAC-SpltPkg-240to759kBtuh-11p5eer
HV345	AC-18668	240 - 760 KBTU/H, EER = 12.5 AND MIN IEER = 15.5 Air Source Unitary Air Conditioner DX Equipment	NE-HVAC-airAC-SpltPkg-240to759kBtuh-12p5eer
N/A	AC-18670	240 - 760 KBTU/H – To Code Savings Portion Air Source Unitary Air Conditioner DX Equipment	NE-HVAC-airAC-SpltPkg-240to759kBtuh-10p8eer
HV350	AC-18671	760 - KBTU/H, EER = 10.2 AND MIN IEER = 11.6 Air Source Unitary Air Conditioner DX Equipment	NE-HVAC-airAC-SpltPkg-gte760kBtuh-10p2eer
HV351	AC-18672	760 - KBTU/H, EER = 11 AND MIN IEER = 12.3 Air Source Unitary Air Conditioner DX	NE-HVAC-airAC-SpltPkg-gte760kBtuh-11p0eer

		Equipment	
HV352	AC-18673	760 - KBTU/H, EER = 12 AND MIN IEER = 13.8 Air Source Unitary Air Conditioner DX Equipment	NE-HVAC-airAC-SpltPkg- gte760kBtuh-12p0eer
N/A	AC-18674	760 - KBTU/H - To Code Savings Portion Air Source Unitary Air Conditioner DX Equipment	NE-HVAC-airAC-SpltPkg- gte760kBtuh-10p2eer

Energy savings values vary by building types, building vintages, and climate zones. For this work paper, all DEER COM building types along with “existing” (weighted DEER vintages) building vintage and all California CEC climate zones were used.

To Code Savings Portion Measures

The To-Code Savings Portion measures in this work paper are the savings from retrofitting customer existing equipment (various SEER values) to code-compliant equipment. The savings were determined by subtracting the “AStdWB” savings from the “APreWB” savings for the above code ACs and HPs. The result was the difference between customer existing equipment and above code equipment.

Example Calculation: (11.5 EER) 65to134kBtuh Packaged Air Conditioner, SCE, COM, CZ 06

DEER2015 savings:

EnergyImpactID	APreWBkWh	APreWBkW	APreWBtherm	AStdWBkWh	AStdWBkW	AStdWBtherm
NE-HVAC-airAC-SpltPkg- 65to134kBtuh- 11p0eer	375	0.134	-1.65	30.3	0.0298	0

kWh Savings = 375 – 30.3 = 344.7 kWh

kW Reduction = 0.134 - 0.0298 = 0.1042 kW

Therm Savings = -1.65 - 0 = -1.65 therms

See accompanying calculation spreadsheet for complete list of measure case savings.

Gas Energy Savings

Therm savings were downloaded from DEER2017 directly.

Therm savings values vary by building types, building vintages, and climate zones. For this work paper, all DEER COM building types along with “existing” (weighted DEER vintages) building vintage and all California CEC climate zones were used.

SECTION 3. LOAD SHAPES

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

Building Types and Load Shapes

Building Type	Load Shape	E3 Alternate Building Type
COM	DEER:HVAC_Split-Package_AC	NON_RES

SECTION 4. COSTS

The Base Case, Measure Case, and Incremental Costs were surveys on distributors based on 2016 proposed efficiency tiers and interpolated to DEER 2017 tiers. There is attachment #2 in the appendix to show the tiers and findings.

Labor hours and labor hourly rates were taken from labor cost recommended values from Large Packaged DX (>5 Tons) documented in the 2010 -2012 W0017 Ex Ante Measure Cost Study, Table 4-3.

4.1 BASE CASE COST

All cost documentation was taken and estimated (interpolated) when applicable using DEER Tiers from distributor data.

4.2 MEASURE CASE COST

All cost documentation was taken and estimated (interpolated) when applicable using DEER Tiers from distributor data.

4.3 FULL AND INCREMENTAL MEASURE COST

See Attachment 2 for full and incremental measure cost.

Full and Incremental Measure Cost Equations

Installation Type	Incremental Measure Cost	Full Measure Cost	
		1 st Baseline	2 nd Baseline
ROB	$(MEC + MLC) - (BEC + BLC)$	$(MEC + MLC) - (BEC + BLC)$	N/A
NEW/NC			
RET/ER	$(MEC + MLC) - (BEC + BLC)$	MEC + MLC	$(MEC + MLC) - (BEC + BLC)$
REF	$(MEC + MLC) - (BEC + BLC)$	MEC + MLC	N/A
REA	MEC + MLC	MEC + MLC	N/A

MEC = Measure Equipment Cost; MLC = Measure Labor Cost
 BEC = Base Case Equipment Cost; BLC = Base Case Labor Cost

ATTACHMENTS

1. PGECO HVC128 Unitary AC R9.xlsx
2. Distributor survey of IMC.xlsx

REFERENCES

1. References rev2015.xlsx

[31]
[215]
[351]
[355]
[422]
[436]

APPENDIX A: FULL LOAD COOLING EFFICIENCY OR PART LOAD COOLING EFFICIENCY AS A PROGRAM REQUIREMENT

The purpose of this addendum is to establish the basis for using full load cooling efficiency *or* part load cooling efficiency as a program requirement, rather than requiring both a minimum full load cooling efficiency *and* a minimum part load cooling efficiency. Full load efficiency requirements are based on the energy efficiency rating (EER) for all equipment categories. Part load efficiency requirements are based on energy efficiency ratio (IEER) for units with capacities greater than 5.4 tons.

The Commercial HVAC Distributor Incentive Program (the Program) is designed to encourage distributors to stock and upsell equipment that is more efficient than the state and federal code baseline. Allowing equipment to qualify for the Program based on either the full load or part load efficiency more accurately reflects the actual performance improvements in the HVAC market and allows a greater number of high efficiency units to qualify for program incentives. Requiring both full load and part load efficiency requirements would eliminate many energy efficient HVAC units from qualifying for program incentives, which would send the wrong signal to the HVAC marketplace. This would result in higher numbers of standard efficiency HVAC units being installed and in lost energy savings for the life of the HVAC unit.

The 2010-2012 Program unit savings values, documented in Program Work Papers, are based on data taken from DEER2008. DEER measure data is based on EER ratings for units with capacities greater than 5.4 tons. Therefore, deemed unit savings assume one EER value for all equipment within a given measure code and do not depend on IEER ratings. The deemed unit savings do not account for the range of equipment efficiency ratings within a given measure code.

Based on current 2010-2012 Program data, units are being incentivized with efficiencies that are both lower and higher than the efficiency of the DEER measure used by the Program to calculate and claim energy and peak demand reduction. We found that the average efficiency of incentivized equipment is higher than the program minimum efficiency used to calculate energy savings in most cases. Further analysis revealed that overall, the actual Program savings (using actual equipment efficiency versus program measure case efficiency) would be higher than the deemed savings based on EER alone.

The following sections provide background on the equipment ratings, examples of the impact of the program structure, and results from program data analysis.

Background on Energy Efficiency Ratings

HVAC equipment is rated at both full load and part load conditions under test methods established by the Air-Conditioning, Heating and Refrigeration Institute (AHRI). Equipment with capacities less than 5.4 tons are rated using the Energy Efficiency Ratio (EER) for full load conditions, and the Seasonal Energy Efficiency Ratio (SEER) for seasonal conditions. Since January 1, 2010, equipment with capacities greater than 5.4 tons has been rated using EER at full load conditions and Integrated Energy Efficiency Ratio (IEER) for part load conditions.

- IEER is a method of measuring the energy efficiency performance of commercial HVAC units that are capable of part load operation over a defined range of part load conditions. The IEER test methods

are defined in ARI Standard 340/360-2007. The IEER serves as a good method of comparing the part load efficiency of various HVAC units.

- IEER is a weighted average of ratings at different loads, which is more typical of a HVAC system's actual dynamic operation.
- The HVAC industry uses IEER to calculate energy savings since over 90% of the run hours are at part load conditions. Therefore, IEER is a more accurate indicator of the customer energy cost.
- Manufacturers design for IEER and not EER.
- EER is a method of measuring full-load energy efficiency performance of commercial HVAC units under static conditions. The EER is the static ratio of a HVAC system's cooling capacity (Btu/h) divided by the energy usage (Watts) at 100% loaded conditions. The EER test methods are defined in AHRI Standard 210/240-2008 and ANSI/AHRI Standard 340/360-2007.
- SEER is a method of estimating seasonal energy efficiency performance. The SEER rating is measured at conditions that more closely reflect the changing operational conditions during the cooling season. It is not the same as the IEER because the equipment measured does not have the capability to operate at part load. The SEER test method is defined in AHRI Standard 210/240-2008.

Most HVAC systems operate at part load condition a majority of the time, and the better a system is designed for part load operation, the more energy it will save. Systems with a high IEER will therefore save more energy (kWh) than systems with a lower IEER. When an HVAC system operates at part load, the condensing coil surface area relative to the system design load increases, lowers the refrigerant temperature, and enables the HVAC system to operate at a reduced pressure. The reduced pressure decreases the system electric demand/energy usage and in turn increases system efficiency at part load operation.

Qualifying Equipment Ratings in 2010-2012 Program

According to the AHRI equipment directory, the maximum IEER rating for each equipment category far exceeds the program requirements. As shown in the following Table D-1, the difference in IEER values are much higher than the difference in maximum EER compared to its program requirements (e.g. 60% greater IEER vs. 16% greater EER for 65-134 kBtuh), indicating that manufacturers are emphasizing part load performance over peak performance in response to the actual operating conditions, especially in California's climate. This also indicates a greater savings potential from incentivizing on IEER than EER.

Table B-1 Summary of Qualifying Equipment Ratings in 2010-2012 Program

Equipment Category	65-134 kBtuh		135-239 kBtuh		240-759 kBtuh		≥760 kBtuh	
	Tier 1	Tier 2	Tier 1	Tier 2	Tier 1	Tier 2	Tier 1	Tier 2
Program Required EER	11.5	12.0	11.5	12.0	10.5	10.8	10.0	10.2
Maximum EER in AHRI / % Above Tier 2 Req.	13.9 / 16%		12.8 / 7%		12.8 / 19%		12.9 / 26% *	
Program Required IEER	11.7	12.2	11.7	12.2	10.6	10.9	10.1	10.3
Maximum IEER in AHRI / % Above Tier 2 Req.	19.5 / 60%		18.7 / 53%		15.4 / 41%		14.7 / 43% *	

* Unitary equipment ≥ 760 kBtuh is not in AHRI so program data was used to estimate the maximum EER and IEER.

The next Table D-2 shows the percentage of equipment that qualified for the program under either the EER or IEER rating or under both ratings. A majority of the participating equipment qualified under either IEER or EER, but not both ratings, and most of the equipment that qualified under one rating qualified under the IEER part load requirement with an average IEER higher than the program minimum efficiency. Had the program required the equipment to meet both EER and IEER ratings, 79% of the equipment would not have qualified.

Table B-2 Program Weight of Qualified Equipment

Qualified Under EER	Qualified Under IEER	Qualified Under Both
31%	48%	21%