**Work Paper PGECOHVC142**

**VRF Nonres**

**Revision # 1**

**Pacific Gas & Electric Company**

**Customer Energy Solutions**

**Variable Refrigerant Flow Nonresidential Systems**

**Measure Codes S287, S288, S289, S290**

**Revision 0**

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Applicable Measure Codes:** | **S287, S288, S289, S290** |
| **Measure Description:** | S287 and S289 replace existing rooftop packaged air conditioners and heat pumps with more efficient Variable Refrigerant Flow units with or without heat recovery.  S288 and S290 replace existing VAV HVAC equipment with Variable Refrigerant Flow units with or without heat recovery. |
| **Energy Impact Common Units:** | Per Ton of AC. |
| **Base Case Description:** | Source: PG&E Calculations of energy and demand usage of existing rooftop packaged unit base case and existing VAV base case. |
| **Base Case Energy Consumption:** | Source: PG&E Calculations using EnergyPro v5.1.5.1 with capability to model variable refrigerant flow. |
| **Measure Energy and Demand Consumption:** | Source: PG&E Calculations using EnergyPro v5.1.5.1 with capability to model variable refrigerant flow. |
| **Energy and Demand Savings (Base Case – Measure Case)** | Source: PG&E Calculations in EnergyPro v5.1.5.1. Base consumption averages .37kW, 912kWh, and 18Therms per ton. |
| **Costs Common Units:** | $ per ton |
| **Base Case Equipment Cost ($/unit):** | The base case cost range is $1000/ton to $1400/ton. |
| **Measure Equipment Cost ($/unit):** | Source: PG&E Calculations, from distributor estimates. $2100/ton for heat pump (HP); $2700/ton for heat recovery (HR). |
| **Measure Incremental Cost ($/unit):** | Source: Difference between base case cost and measure case cost. The incremental cost is equal to the difference between measure cost and base case cost.  ROB = measure equipment cost – base case equipment cost, range $700/ton to $1700/ton.  RET = measure equipment plus labor including overhead and profit. RET or early retirement (ER) is not included in program as of April 2012. |
| **Effective Useful Life (years):** | Source: DEER 2008[[1]](#endnote-1) 15 years is based on Nonresidential “Air Conditioners / Heat Pumps (split and unitary),” from updated EUL\_Summary\_10-1-08. |
| **Program Type:** | Replace on Burnout (ROB), Upstream Rebate |
| **Net-to-Gross Ratios:** | Source: DEER 2016; NTG =0.75 “All package and split system AC & HP replacements.”[[2]](#endnote-2) |
| **Important Comments:** “OTR”-This code stands for “Other” building type and it is only used when the customer doesn’t select a building type in the application or the building type doesn’t fall under any of the DEER approved building types. “OTR” building type savings are calculated using the "minimum kwh savings row" of valid DEER building types. If all kwh are zero, use minimum kw row. If all kwh and kw are zero, use minimum therm. For a lighting measure with all building types, the “MTL” building type will be equivalent to OTR because it is the lowest hours of operation. This is a PG&E Administrative type, additional to any DEER types listed. | |

**AT A GLANCE MEASURE LIST**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  | **1st Baseline** | | | | | | | | **2nd Baseline** | | | | | | | |  |  |  |  |  |  |
| Measure Code | Version Source | Measure  Description | Measure Application Type | Building Type | Building Vintage | Climate Zone | Unit Definition | KW Peak Elec Demand Reduction | KWh Electric Savings | THM Gas Savings | (EUL) LIFE CYCLE | Base Case Cost ($/unit) | Measure Cost ($/unit) | Labor Cost ($/unit) | IMC Incremental  Measure Cost ($/unit) | KW Peak Electric Demand Reduction | KWh Electric Savings | THM Gas Savings | LIFE CYCLE | Base Case Cost ($/unit) | Measure Cost ($/unit) | Labor Cost ($/unit) | IMC Incremental  Measure Cost ($/unit) | GRR\_  kW | GRR\_  kWh | GRR\_  therm | NTG | Implementation Method  [DI, DD, I] | ISR |
| S287 |  | HVAC\_VARIABLE\_REFRIG\_FLOW\_HEAT\_PUMP\_<\_80\_TONS | ROB | OFS | EX | Z01 | Cap-ton | 0.32 | 283.1 | 0.21 | 15 | $1,000.00 | $2,100.00 | $0 | $1,100.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | .75 | I | 1 |
| S287 |  | HVAC\_VARIABLE\_REFRIG\_FLOW\_HEAT\_PUMP\_<\_80\_TONS | ROB | OFS | EX | Z02 | Cap-ton | 0.00 | 336.3 | 1.09 | 15 | $1,000.00 | $2,100.00 | $0 | $1,100.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | .75 | I | 1 |
| S287 |  | HVAC\_VARIABLE\_REFRIG\_FLOW\_HEAT\_PUMP\_<\_80\_TONS | ROB | OFS | EX | Z03 | Cap-ton | 0.34 | 319.6 | 0.47 | 15 | $1,000.00 | $2,100.00 | $0 | $1,1 00.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | .75 | I | 1 |
| S287 |  | HVAC\_VARIABLE\_REFRIG\_FLOW\_HEAT\_PUMP\_<\_80\_TONS | ROB | OFS | EX | Z04 | Cap-ton | 0.61 | 417.0 | 0.32 | 15 | $1,000.00 | $2,100.00 | $0 | $1,100.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | .75 | I | 1 |
| S287 |  | HVAC\_VARIABLE\_REFRIG\_FLOW\_HEAT\_PUMP\_<\_80\_TONS | ROB | OFS | EX | Z05 | Cap-ton | 0.54 | 383.9 | 4.72 | 15 | $1,000.00 | $2,100.00 | $0 | $1,100.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | .75 | I | 1 |
| S287 |  | HVAC\_VARIABLE\_REFRIG\_FLOW\_HEAT\_PUMP\_<\_80\_TONS | ROB | OFS | EX | Z11 | Cap-ton | 0.26 | 522.38 | 20.95 | 15 | $1,000.00 | $2,100.00 | $0 | $1,100.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | .75 | I | 1 |
| S287 |  | HVAC\_VARIABLE\_REFRIG\_FLOW\_HEAT\_PUMP\_<\_80\_TONS | ROB | OFS | EX | Z12 | Cap-ton | 0.26 | 522.38 | 20.95 | 15 | $1,000.00 | $2,100.00 | $0 | $1,100.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | .75 | I | 1 |
| S287 |  | HVAC\_VARIABLE\_REFRIG\_FLOW\_HEAT\_PUMP\_<\_80\_TONS | ROB | OFS | EX | Z13 | Cap-ton | 0.09 | 683.88 | 30.74 | 15 | $1,000.00 | $2,100.00 | $0 | $1,100.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | .75 | I | 1 |
| S287 |  | HVAC\_VARIABLE\_REFRIG\_FLOW\_HEAT\_PUMP\_<\_80\_TONS | ROB | OFS | EX | Z16 | Cap-ton | 0.14 | 645.32 | 26.44 | 15 | $1,000.00 | $2,100.00 | $0 | $1,100.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | .75 | I | 1 |
| S287 |  | HVAC\_VARIABLE\_REFRIG\_FLOW\_HEAT\_PUMP\_<\_80\_TONS | ROB | ESE | EX | Z01 | Cap-ton | 0.18 | 742.95 | 20.37 | 15 | $1,000.00 | $2,100.00 | $0 | $1,100.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | .75 | I | 1 |

**Note: For the complete list of Measures, refer to the accompanying calculation spreadsheet listed in References.**

# Work Paper Approvals

|  |  |
| --- | --- |
|  |  |
| **Grant Brohard**  Manager, Technical Product Support | **Date** |
| **Paola Benassi**  Manager, CES Core Products HVAC | **Date** |

# Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Revision #** | **Date** | **Section-by-Section Description of Revisions** | **Author (Company)** |
| **Revision 0** | **5/1/2012** | **Original work paper: PGECOHVC142 Variable Refrigerant Flow Nonres R0** | **Judith Jennings (PG&E)**  **Calculations: Jun Furuta, Elizabeth Joyce, Alex MacCurdy, Russell Torres (Energy Solutions)** |
| Revision 0 | 8/28/2012 | **PGECOHVC142 Variable Refrigerant Flow Nonres R0**  Changed vintage and climate zone designations to ED standard, set GRRs to 1, added OTR explanation to AAG summary and Section 2,  Removed all attachments, and changed date. | Judith Jennings |
| Revision 1 | 1/1/2016 | **PGECOHVC142 Variable Refrigerant Flow Nonres R1**  Updated NTG to 0.75. | Henry Liu |

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# Section 1. General Measure & Baseline Data

## 1.1 Product Measure Description & Background

***Catalog Description –*** Variable Refrigerant Flow systems can replace existing air conditioning or heat pump systems with more efficient units that provide refrigerant to conditioned zones depending on their need for cooling (or heating) without ductwork. Outside air is provided via a separate system, and so is not dependent on the flowrate of conditioned air. Duct losses are eliminated, though existing ductwork may be reusable to supply outside air.

***Program Restrictions and Guidelines***

***Terms and Conditions:***

* ***Must be a PG&E nonresidential electric customer***
* ***Must take the place of existing rooftop packaged units or VAV systems***

***Market Applicability: This program applies to nonresidential customers with unitary or split-system AC or HP equipment or VAV systems, through the upstream rebate program.***

## 1.2 Product Technical Description

Table 1 DEER Use and Technology Table



Variable Refrigerant Flow (VRF) systems are multi-zone units that circulate refrigerant from an outdoor compressor to multiple indoor evaporator units. VRFs incorporate inverter-driven compressors that modulate the flow of refrigerant in the system and ECM fans that adjust air flow in response to the actual cooling and heating demand. Thus, they provide significantly better part load performance over conventional packaged and split-systems, while maintaining more precise temperature control. Different combinations of indoor ductless and ducted units can be utilized for these systems depending on the application and zone layout of the building.

VRF systems are modular in design. The individual outdoor units range in size from 6 tons up to 30 tons. More capacity can be added by increasing the number of outdoor units as required for the application. Unlike traditional packaged multi-zone air conditioners that supply conditioned air to all zones and often must reheat the supply air to accommodate different conditions in diverse zones, VRF systems control each zone by modulating the amount of refrigerant that is delivered to each evaporator fan coil unit within the zone. Refrigerant is delivered to each zone depending on its need, and zones with intermittent demand can be turned down or completely off during times of little to no cooling or heating demand. The inverter-controlled compressor responds to changing demand by varying its speed, effectively reducing capacity and energy consumption during part-load conditions.

## 1.3 Transaction Types

This work paper deals with Replace on Burnout (ROB) measures for two types of VRF systems, Heat Pumps (HP) and Heat Recovery (HR) units >65kBtu/h. A heat pump can either be in heating or cooling mode at any one time. A heat recovery unit can provide heating and cooling simultaneously to different zones by removing heat from a zone requesting cooling, and delivering it to a zone requesting heat, thereby reducing compressor load and increasing energy savings.

This work paper documents the energy savings from using VRF units compared to two Title 24 baselines:

1. single-zone packaged DX air conditioners with gas heating, and
2. multi-zone packaged DX variable air volume (VAV) Air Conditioners with a separate gas boiler and reheat.

VRF systems are appropriate for Replace on Burnout (ROB) for each of these baseline system types. Early retirement will be added to the work paper if it becomes clear that there are cases where this baseline is appropriate.

The delivery method for this work paper is Upstream Programs - Upstream Incentive.

## 1.4 Product Base Case and Measure Case Data

### 1.4.1 DEER Base Case and Measure Case Information

Variable Refrigerant Flow units are not included in the 2011 Database for Energy Efficient Resources (DEER). Because of the multi-zone, inverter-controlled operation, it was not possible to extrapolate data from the standard package and split systems.

Instead, energy savings were determined using the EnergyPro v5.1.5.1 [B] building energy modeling software. EnergyPro is certified for demonstrating compliance with the current Title 24 code for non-residential/high-rise residential/hotel-motel buildings using the performance approach. The VRF module is pending final review by the California Energy Commission for compliance with the Title 24 ACM. It uses the DOE-2.1E v119 software engine licensed from the Department of Energy. The application for the VRF module to comply with Title 24 Alternative Calculation Method is still pending final review by the California Energy Commission.

The EnergyPro models developed for this work paper include a 7200 sq. ft., two-story office building (small office), a 41,500 sq. ft., three-story office building (large office), and a 24,000 sq. ft., single-story school building (middle school). All buildings were simulated using heat pump and heat recovery configurations and in all climate zones served by Pacific Gas and Electric (PG&E). The average system size for the 7200 sq. ft. building was 18 tons, the average size for the 41,500 sq. ft. building was 77 tons, and the average size for the 24,000 sq. ft. building was 74 tons.

**Delta Wattage Assumption (ΔW):** Wattage and kWh for the base case units (Split or Packaged AC or HP units or VAV systems) and the measure case units (VRF heat pump units with or without heat recovery) are calculated in EnergyPro.

**EUL and RUL:** The EUL and RUL for base cases were downloaded directly from DEER 2011 directly using the split and unitary system AC and HP descriptions HVAC-HtCl and HVAC-SpCl (Version source D08 V 2.05).

**EUL: 15 years**

**RUL: 5 years (not used in this version of the work paper, due to lack of data on unit condition at time of retirement),**

**Therms Savings Assumption (ΔTh):** Therm savings are calculated in EnergyPro along with the Wattages and kWh.

**Hours of Operation**: Hours of operation are taken from DEER 2008 (now incorporated into DEER 2011) and the T24 ACM according to building type. In this work paper, only Small Office, Large Office, and Middle School building types are covered.

**Net-to-Gross Assumption:** Table 1 below summarizes all applicable DEER based Net-to-Gross ratios for programs that may be used by this measure.

Table 2 Net-to-Gross Ratios

|  |  |
| --- | --- |
| **Description** | **NTG** |
| DEER--NonRes-sAll-mHVAC-DX-up | 0.75 |

The NTG Ratios in Table 1 are appropriate for the measure(s) because:

* These measures are replacements for Nonresidential packaged and split system AC and HP units.
* This is a nonresidential upstream HVAC DX (direct expansion) program.

**In service rate:** VRF measures are installed when purchased, so the ISR is 1.0.

### 1.4.2 Codes & Standards Requirements Base Case and Measure Information

**Title 20*:*** Air conditioning and heat pump equipment are regulated under Title 20 of the California Energy Regulations[[3]](#endnote-3) as noted in Table 2. Units are required to have a TXV.

Table 3 Efficiency Requirements for AC and HP Equipment

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Title 20 Std. Description** | **Base or Measure Case** | **Capacity** | **Minimum Value** | **Code Source or Reference** |
| Single package air-cooled heat pumps | *Measure* | < 65,000 | 11.6 EER  13.0 SEER  7.7 HSPF | *Table C-6, Title 20,2008* |
| Other air-cooled heat pumps | *Measure* | < 65,000 | 11.6 EER  13.0 SEER  7.9 HSPF | *Table C-6, Title 20,2008* |
| Air-source heat pumps | *Measure* | ≥ 65,000 and  < 135,000 | 11.0 EER  3.4 at 47° F. COP  2.4 at 17° F. COP | *Table C-6, Title 20,2008* |
| Air-source heat pumps | *Measure* | ≥ 135,000 and  < 240,000 | 10.8 EER  3.3 at 47° F. COP  2.2 at 17° F. COP | *Table C-6, Title 20,2008* |

**Title 24:** The measures described in this work paper are regulated under Title 24 of the California Energy Regulations[[4]](#endnote-4). An application submitted on behalf of four VRF manufacturers by EnergySoft, the developer of EnergyPro, is pending approval by the California Energy Commission to accept VRF modeling using Energy Pro under the Title 24 Alternative Calculation Method (ACM). VRFs are currently sold in California through a waiver issued by the Department of Energy. The following tables were taken from Tables 112-A & 112-B (page 51) of the 2008 Title 24 Residential & Nonresidential Regulations/Standards.

Table 4 Minimum 2008 Title 24 Efficiencies for Packaged

Air Conditioning Units (single zone or VAV) with Electric Heat

|  |  |
| --- | --- |
| **Unit Capacity** | **Minimum EER/SEER**  **(After January 1, 2010)** |
| <65kBtuh | 13.0 SEER |
| ≥65kBtu/h & <135 kBtu/h | 11.2 EER |
| ≥135kBtu/h & <240 kBtu/h | 11.0 EER |
| ≥240kBtu/h & <760 kBtu/h | 10.5 EER |
| ≥760 kBtu/h | 9.7 EER |

Table 5 Minimum 2008 Title 24 Efficiencies for Packaged Heat Pumps.

|  |  |  |
| --- | --- | --- |
| **Unit Capacity (Cooling)** | **Cooling**  **Minimum EER/SEER**  **(After January 1, 2010)** | **Heating**  **Minimum COP/HSPF (After January 1, 2010)** |
| <65kBtuh | 13.0 SEER | 7.7 HSPF |
| ≥65kBtu/h & <135 kBtu/h | 11.0 EER | 3.3 COP |
| ≥135kBtu/h & <240 kBtu/h | 10.6 EER | 3.2 COP |
| ≥240kBtu/h | 9.5 EER | 3.2 COP |

*Note: Deduct 0.2 from the required EER for units with a heating section other than electric resistance heat.*

**Federal Standards:** The California standards exceed Federal requirements.

**Hours of Operation:** The DEER hours of operation refer to non-CFLequivalent full-load lighting hours. Title 24 ACM schedule uses 4300 hours for HVAC operation for offices.

Table 6 Hours of Operation

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Building type**  **(DEER code)** | **Building Vintage** | **Climate Zone** | **DEER 2011[[5]](#endnote-5) Non-CFL Lighting EFLH hrs/yr** | **DEER 2011 sum of occupied hours** | **T24 ACM HVAC Hours of Operation hrs/yr** |
| Large Office (OFL) | AV | ALL | 2641 |  | 4300 |
| Small Office (OFS) | AV | ALL | 2594 |  | 4300 |
| Middle School (ESE) | AV | ALL | 2285 | 1488[[6]](#footnote-1) | tba |

**Costs:**

The [Base Case / Measure Case / Incremental] Costs were developed from early results of the SCE VRF program for Large and Small Offices for 2010-2011. The cost is listed by system capacity and features in Table 7.

Table 7 Base Case and Measure Case Costs Per Ton

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Costs ($/ton)** | | |  |
| **System Type/Size** | **Base Case** | **Measure Case** | **IMC** | **DEER Version** |
| HVAC\_VARIABLE\_REFRIG\_FLOW\_HEAT\_PUMP\_<\_80\_TONS | 1000 | 2100 | 1100 | SCE VRF program |
| HVAC\_VARIABLE\_REFRIG\_FLOW\_HEAT\_PUMP >=\_ 80\_TONS | 1400 | 2100 | 700 | SCE VRF program |
| HVAC\_VARIABLE\_REFRIG\_FLOW\_HEAT\_RECOVERY\_<\_80\_TONS | 1000 | 2700 | 1700 | SCE VRF program |
| HVAC\_VARIABLE\_REFRIG\_FLOW\_HEAT\_RECOVERY\_ >=\_ 80\_TONS | 1400 | 2700 | 1300 | SCE VRF program |

**Effective Useful Life:**

The Effective Useful Life estimates were downloaded from DEER directly for the HVAC - Split/Package category. In the EUL\_Summary\_10-1-08.xls[[7]](#endnote-6) Commercial AC class is set to 15 years.

Table 8 Effective Useful Life

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Building Type** | **Bldg Vintage** | **Climate Zone** | **EUL (yrs)** | **RUL (yrs)** | **DEER Version** | **Impact IDs** |
| ALL | AV | ALL | 15 | n/a | DEER 2011 | Comm AC |

### 1.4.3 EM&V, Market Potential, and Other Studies – Base Case and Measure Case Information

M&V studies being carried out currently will apply to these measures. Information on these studies will be available and this work paper will be updated as soon as possible after the studies are completed.

***1.4.3.1 SCE/EPRI Investigations[[8]](#endnote-7)***

No information yet available.

***1.4.3.2 Northwest Utilities Investigations[[9]](#endnote-8)***

No information yet available.

### 1.4.5 Time-of-Use Adjustment Factor

As directed by the CPUC in decision 06-06-063 dated June 29, 2006, time-of-use (TOU) adjustment factors are to be applied for residential AC and commercial AC (direct-expansion cooling) measures only. The specific TOU adjustment factors are inherent in the avoided-cost calculation performed in the E3 calculator. In order to apply the TOU adjustment factor correctly to each measure, the following equation was used to calculate the “% Eligible for TOU AC Adjustment” value found in the summary table:



where *kWAC*is the kW savings associated with the AC unit, and *kWTotal* is the total kW savings for the sum of kW measures. The TOU for this measure is 100%.

# Section 2. Calculation Methods

Energy efficiency measures that involve a change in source from gas to electricity (or vice-versa) are required to meet three tests:

1. Must not increase source BTU consumption.
2. Must have a TRC and PAC greater than one.
3. Must not adversely impact the environment.

The calculations in this work paper show that VRF systems pass the first test. These measures also meet the TRC and PAC requirements, and thus pass the second test. Because the measures save energy, they also reduce greenhouse gases, reducing the negative impact on the environment.

## 2.1 Electric Energy Savings Estimation Methodologies

The basic equations describing energy savings are given as:

**∆Watts/ton:** The demand difference (watts per ton) is simply the difference between the electric demand of the base unit and the electric demand of the energy-efficient unit.

**∆Watts/ton = Base Case Watts/ton - Measure Case Watts/ton**

where: Base Case Watts/ton represents code/industry standard base unit demand per ton of air conditioning capacity.

**Annual Electric Savings:**

**Energy Savings [kWh/ton = (∆Watts/ton) x (hours/day)x(days/year)**

**1,000 Watts / kW**

In an actual HVAC savings calculation, the multiple factors affecting energy use require a complex analysis, based on these basic equations but accounting for many factors including occupancy schedules, weather, building construction type, vintage, and climate zone.

Energy savings for VRF are calculated using EnergyPro software, version 5.1.5.1. A VRF module was developed for this software using manufacturer data. This version has been reviewed and found to be applicable for simulating current VRF equipment for the end uses specified in this work paper.[[10]](#endnote-9)

* This measure includes HVAC interactive effects savings because it is calculated in a complete building simulation model that uses the DOE2.1E program.
* This measure is not an Early Retirement (ER)measure. If required in the statewide update for 2013, ER data will be added.

The previous version of the VRF work paper, developed for SCE, used similar models and an earlier version of the EnergyPro software. To verify the accuracy of the EnergyPro modeling and analysis performed for that work paper, representative building models for all the VRF and base case systems were reviewed by Martyn Dodd, the developer of EnergyPro and principal of EnergySoft, LLC. He also reviewed the data summary from all the simulation reports developed in EnergyPro as well as the average savings, demand reduction and duct loss analyses for correct interpretation of the simulation results.[[11]](#endnote-10)

“OTR”-This code stands for “Other” building type and it is only used when the customer doesn’t select a building type in the application or the building type doesn’t fall under any of the DEER approved building types. “OTR” building type savings are calculated using the "minimum kwh savings row" of valid DEER building types. If all kwh are zero, use minimum kw row. If all kwh and kw are zero, use minimum therm. For a lighting measure with all building types, the “MTL” building type will be equivalent to OTR because it is the lowest hours of operation. This is a PG&E Administrative type, additional to any DEER types listed.

Table 9 Small Office VRF Heat Pump vs. Single Zone Packaged AC

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Average Demand Reduction** | **Average Annual Energy Savings** | **Average Annual Gas Savings** |
| **CZ** | **(kW/ton)** | **(kWh/ton)** | **(Therms)** |
| **01** | 0.84 | 2089 | 8.53 |
| **02** | 0.84 | 2089 | 8.53 |
| **03** | 0.66 | 2092 | 15.8 |
| **04** | 0.71 | 2088 | 14.2 |
| **05** | 0.67 | 2238 | 10.4 |
| **11** | 0.91 | 2086 | 16.0 |
| **12** | 0.80 | 1990 | 11.3 |
| **13** | 0.98 | 2364 | 7.62 |
| **16** | 0.87 | 2053 | 38.2 |

Table 10Small Office VRF Heat Recovery vs Single Zone Packaged AC

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Average Demand Reduction** | **Average Energy Savings** | **Average Annual Gas Savings** |
| **CZ** | **(kW/ton)** | **(kWh/ton)** | **(Therms)** |
| **01** | 0.83 | 2064 | 8.53 |
| **02** | 0.83 | 2064 | 8.53 |
| **03** | 0.66 | 2077 | 15.8 |
| **04** | 0.71 | 2062 | 14.2 |
| **05** | 0.66 | 2222 | 10.4 |
| **11** | 0.75 | 2047 | 16.0 |
| **12** | 0.79 | 1954 | 11.3 |
| **13** | 0.97 | 2323 | 7.62 |
| **16** | 0.87 | 2031 | 38.2 |

## 2.2. Demand Reduction Estimation Methodologies

The basic concept of Demand Reduction is described by the following equation:

**EUL Demand Reduction [kW/ton] = (EUL ∆Watts/ton) x (DEER Peak Hour Load Share) 1,000 Watts s/ kW**

Just as for the energy (kWh/ton) calculation, the actual demand calculation is much more detailed and is carried out in EnergyPro.

## 2.3. Gas Energy Savings Estimation Methodologies

* Gas savings associated with this measure are due to switching from gas to electric (heat pump) heating energy. The calculations are based on an average base case that accounts for the diversity of existing heating systems in the PG&E service territory.
* Gas estimates include calculated interactive effects.

**Annual Gas Savings:**

Energy Savings [therms/ton] = Annual Base Gas Usage - Annual Energy-Efficient Gas Usage

# Section 3. Load Shapes

## 3.1 Base Case Load Shapes

The load shape chosen for this measure is the HVAC\_Split-Package\_AC from DEER2011[[12]](#endnote-11).

Table 11 Target Sectors and Load Shapes

|  |  |
| --- | --- |
| **Building Type** | **Load Shape** |
| Office - Small | HVAC\_Split-Package\_AC |
| Office - Large | HVAC\_Split-Package\_AC |
| Education – Secondary School | HVAC\_Split-Package\_AC |

## 3.2 Measure Load Shapes

The measure load shape is the same as the base case load shape, HVAC\_Split-Package\_AC.

# Section 4. Base Case & Measure Costs

## 4.1 Base Case(s) Costs

**ROB**

For this measure category, the base case cost is used to calculate the incremental measure cost.

**Base Case Cost**

DEER 2011 did not provide any cost information on this type of equipment. The base case equipment (material) costs were obtained from Energy Solutions by averaging data collected from RS Means[[13]](#endnote-12) and interviews with HVAC distributors. Because this is an upstream measure, labor costs are not included. The base case costs represent the equipment cost for replacing the old equipment with the same type of equipment. These values are shown in Table 5, along with the referenced replacement equipment.

Table 12 Sample Base Case Costs

|  |  |  |
| --- | --- | --- |
| **Measure Name (Title 24 Baseline)** | **Base Case Equipment Cost/ton** | **RS Means 2010 Reference** |
| Single-zone Packaged DX Air Conditioner with gas heating | $1,000 | 23 74 33.10 1140  5 ton cooling,  112 MBH heating |
| Single-zone Packaged DX Heat Pump | $1,000 | 23 74 33.10 1310  Electric cool, electric heat  5 ton |
| Multi-zone Packaged DX VAV Air Conditioner with gas boiler and reheat | $1,400 | 23 74 33.10 7130  Multizone, cool/heat,  VAV distribution, 105 ton cooling |

## 4.2 Incremental & Full Measure Costs

### 4.2.1 Full (or Gross) Measure Cost

Gross measure cost is the cost to install an energy efficient measure per the CPUC calculators. This definition implies a different meaning depending on the install type. This measure falls under the ROB category, so labor would be required regardless of the type of equipment installed.

### 4.2.2 Incremental Measure Costs

Incremental Measure Cost is the premium cost to install an energy-efficient measure over the cost of installing a standard measure or code baseline measure. While IMC has a straightforward definition depending on the install type, the equation does vary.

This measure transaction type is ROB. The Incremental Measure Cost (IMC) for ROB is represented by the equation below*[[14]](#footnote-2)*:

IMC = (Measure Equipment Cost + Measure Labor Cost) –

(Base Case Equipment Cost + Base Case Labor Cost)

For this measure, the labor costs are assumed to be the same for the base and the measure cases, so they would cancel out of the above equation. However because this is an Upstream program, the labor costs are not included in the IMC anyway. For either one of these reasons, the above equation becomes:

IMC = (Measure Equipment Cost) – (Base Case Equipment Cost)

The incremental cost is included in the Appendix. A more detailed description of measure cost considerations is given in “Measure Cost rev5 PGE slb4 111111.doc,”[[15]](#endnote-13) in accompanying documents.

References

Measure savings are found in the accompanying spreadsheet HVC142 VRF Nonres\_At-A-Glance Template\_v0 1REV08-23.xlsx.

1. EUL\_Summary\_10-1-08.xls, downloaded from [www.deeresources.com](http://www.deeresources.com) 3/19/2012. [↑](#endnote-ref-1)
2. DEER 2011-NTG\_IncludingCarryoversFromDEER2008\_2011-12-07.xls, found on Deeresources.com [↑](#endnote-ref-2)
3. California Energy Commission, California Code of Regulations, Title 20. Public Utilities and Energy, CEC-140-2008-001-REV1, August 2008. [↑](#endnote-ref-3)
4. California Energy Commission, 2008 California Building Energy Efficiency Standards, Title 24, adopted April 23, 2008, Nonresidential Compliance Manual adopted January 14, 2009. [↑](#endnote-ref-4)
5. CPUC DEER LightingHVACInteractiveEffects\_13Dec2011.xls, downloaded from [www.deeresources.com](http://www.deeresources.com) on 4/5/2012 [↑](#endnote-ref-5)
6. 1488 hrs using the DEER 2008 occupancy schedule of :

   7a-3p WD Jan 7-Apr 5; Apr 13-Jun 14; Aug 19-Dec 15 [↑](#footnote-ref-1)
7. CPUC DEER EUL\_Summary\_10-1-08.xls downloaded from [www.deeresources.com](http://www.deeresources.com) on 2/17/2010. [↑](#endnote-ref-6)
8. SCE/EPRI Investigation in process [↑](#endnote-ref-7)
9. Northwest Utilities Investigations in process [↑](#endnote-ref-8)
10. Jun Furuta, Energy Solutions, January 2012. [↑](#endnote-ref-9)
11. Dodd, Martyn, EnergySoft, LLC, Building models, data analysis, and work paper methodology review, April 2010 [↑](#endnote-ref-10)
12. CPUC DEER DEER2011-HrlyProfiles-PGE-v1.xls, downloaded from [www.deeresources.com](http://www.deeresources.com) on 4/5/2012. [↑](#endnote-ref-11)
13. R. S. Means, Mechanical Cost Data. 2010. [↑](#endnote-ref-12)
14. Note: Various complicated price fluctuations are not addressed in these equations, such as future costs due to inflation in labor, future costs due to deflation in material cost, and other variables that cannot be accurately described at this time. [↑](#footnote-ref-2)
15. Measure Cost rev5 PGE slb4 111111.doc [↑](#endnote-ref-13)