Work Paper SCE13HC036

**Revision 1**

**Southern California Edison**

**Variable Refrigerant Flow Commercial Heat Pumps & Heat Recovery Systems >65kBtu/h**

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Measure Codes** | Various solution codes - See Section 1 |
| **Measure Description** | >= 65 kBtu/hr Variable Refrigerant Flow Heat Pump DX Equipment  >= 65 kBtu/hr Variable Refrigerant Flow Heat Recovery DX Equipment |
| **Base Case Description** | Single-zone Packaged DX Air Conditioners with gas heating  Multi-zone Packaged DX Variable Air Volume (VAV) Air Conditioners with gas heating |
| **Units** | Ton |
| **Energy Savings** | Refer to Excel Calculation Attachment |
| **Full Measure Cost ($/unit)** | Refer to Excel Calculation Attachment |
| **Incremental Measure Cost ($/unit)** | Refer to Excel Calculation Attachment |
| **Effective Useful Life** | 15.0 (DEER EUL ID: HVAC-airHP) |
| **Measure Installation Type** | Replace on Burnout (ROB) |
| **Net-to-Gross Ratio** | 0.75 (NonRes-sAll-mHVAC-DX-up) |
| **Important Comments** | This work paper has a complementary Ex Ante Database data set that will be provided in a separate submission to the California Public Utilities Commission (CPUC). |

# Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Rev** | **Date** | **Author** | **Summary of Changes** |
| 0 | 05/25/2012 | Andres Fergadiotti/SCE | Updated to latest template 2013 v0.1 from WPSCNRHC0036 |
| 1 | 03/21/2016 | Andres Fergadiotti/SCE | -New template update for 2016 program year  -WP effective from 1/1/2016 thru 12/31/2016  -Removed SCE building types  -No value modifications  - Revised NTGR and EUL  - Added GSIA |

# Commission Staff and Cal TF Comments

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Rev** | **Party** | **Submittal Date** | **Comment Date** | **Comments** | **WP Developer Response** |
|  |  |  |  |  |  |

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

# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

Variable Refrigerant Flow (VRF) systems are multi-zone units that circulate refrigerant from an outdoor compressor to multiple indoor fan coil units. Different combinations of indoor ductless and ducted units can be utilized for these systems depending on the application and layout of the building. VRFs incorporate inverter driven compressors and fans that modulate the flow of refrigerant in the system 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.

VRF systems are modular in design. The compressors range in size from 6 tons up to 30 tons and more capacity can be added as needed for the application by increasing the number of outdoor units. Unlike traditional packaged multi-zone air conditioners that must condition all zones and must reheat the supply air to accommodate different temperature set points, VRFs control each zone by modulating the amount of refrigerant that is delivered to each fan coil unit within the zone. Less refrigerant can be delivered to zones with a lower demand and other zones can be completely turned off during times of little to no cooling or heating demand. The inverter controlled compressor responds to the lower demand by reducing its speed and results in an effective reduction in capacity during part load conditions.

This work paper deals with Replace on Burnout (ROB) measures for two types of VRFs, 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 simultaneous heating and cooling by moving heat from a zone being cooled to a zone that requires heating, reducing compressor load and further saving energy.

This work paper will demonstrate the energy savings of VRF units over Title 24 baseline single-zone Packaged DX Air Conditioners with gas heating and multi-zone Packaged DX Variable Air Volume (VAV) Air Conditioners with a separate gas boiler and reheat.

**Base, Standard, and Measure Cases**

|  |  |
| --- | --- |
| **Case** | **Description of Typical Scenario** |
| Measure | >= 65 kBtu/hr Variable Refrigerant Flow Heat Pump DX Equipment  >= 65 kBtu/hr Variable Refrigerant Flow Heat Recovery DX Equipment |
| Existing Condition | Single-zone Packaged DX Air Conditioners with gas heating (Small Office)  Multi-zone Packaged DX Variable Air Volume (VAV) Air Conditioners with gas heating (Large Office) |
| Code/Standard | N/A |
| Industry Standard Practice | N/A |

Measures and Codes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Codes** | | | | **Measure Name** |
| SCG | SDG&E | SCE | PG&E |
|  |  | AC-18793 |  | >= 65 kBtu/hr Variable Refrigerant Flow Heat Pump DX Equipment replacing Package Variable Air Volume |
|  |  | AC-20693 |  | >= 65 kBtu/hr Variable Refrigerant Flow Heat Pump DX Equipment replacing Single Zone Package AC |
|  |  | AC-39286 |  | >= 65 kBtu/hr Variable Refrigerant Flow Heat Pump DX Equipment replacing Single Zone Package Heat Pump |
|  |  | AC-49676 |  | >= 65 kBtu/hr Variable Refrigerant Flow Heat Recovery DX Equipment replacing Package Variable Air Volume |
|  |  | AC-57395 |  | >= 65 kBtu/hr Variable Refrigerant Flow Heat Pump DX Equipment replacing Single Zone Package AC |
|  |  | AC-69593 |  | >= 65 kBtu/hr Variable Refrigerant Flow Heat Recovery DX Equipment replacing Single Zone Package Heat Pump |

New construction measures are expected to fall under Title 24 of the California Energy Regulations, specifically within the Alternative Calculation Method (ACM).

## 1.2 Technical Description

This technology includes multiple indoor evaporators connected to a single condens­ing unit, in which heat is transferred to or from the space directly by circulating refrigerant to evaporators located near or within the conditioned space.

## 1.3 Installation Types and Delivery Mechanisms

This work paper deals with Replace on Burnout (ROB) measures for two types of VRFs, Heat Pumps (HP) and Heat Recovery (HR) units >65kBtu/h.

The delivery method for this workpaper is Upstream Programs - Up-Stream Incentive.

**Installation Type Descriptions**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Installation Type** | **Savings** | | **Life** | |
| 1st Baseline (BL) | 2nd BL | 1st BL | 2nd BL |
| Replace on Burnout (ROB) | Above Code or Standard | N/A | EUL | N/A |

A delivery mechanism is a delivery method paired with an incentive method. Delivery mechanisms are used by programs to obtain program participation and energy savings.

**Delivery Method Descriptions**

|  |  |
| --- | --- |
| **Delivery Method** | **Description** |
| Up-Stream Programs | *See Up-Stream Incentive in the Incentive Method Descriptions table.* |

**Incentive Method Descriptions**

|  |  |
| --- | --- |
| **Incentive Method** | **Description** |
| Up-Stream Incentive | 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

DEER Difference Summary

|  |  |
| --- | --- |
| **DEER Item** | **Used for Workpaper?** |
| Modified DEER methodology | No |
| Scaled DEER measure | No |
| DEER Base Case | No |
| DEER Measure Case | No |
| DEER Building Types | No |
| DEER Operating Hours | No |
| DEER eQUEST Prototypes | Yes |
| DEER Version | DEER 2011 V4.01 |
| Reason for Deviation from DEER | Variable Refrigerant Flow units are not included in the 2011 Database for Energy Efficient Resources (DEER) |
| DEER Measure IDs Used | N/A |

**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 | Nonresidential Package HVAC Equipment: deemed; upstream delivery | 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 RUL value is only applicable to the first baseline period for an RET measure with an applicable code baseline. The relevant EUL and RUL values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| HVAC-airHP | Heat Pumps (air-cooled, split and unitary) | Com | HVAC | 15 | 5 |

### 1.4.2 Codes and Standards Analysis

New construction measures are expected to fall under Title 24 of the California Energy Regulations, specifically within the Alternative Calculation Method (ACM). 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 ACM. VRFs are currently sold in California through a waiver issued by the Department of Energy.

Code Summary

|  |  |  |
| --- | --- | --- |
| **Code** | **Reference** | **Effective Dates** |
| Title 24 (2008) | 2008 Non-Residential Compliance manual, Table 4-3 Minimum Ventilation Requirements | January 1, 2010 |
| Title 20 (2010) | Table K-4 Standards for Federally-Regulated General Service Incandescent Lamps | January 1, 2010 |

The following tables were taken from Table 112-A & 112-B (page 51) of the 2008 Title 24 Residential & Nonresidential Regulations/Standards.

Minimum 2008 Title 24 Efficiencies for Packaged

**Air Conditioning Units (single zone or VAV)**

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

Note: Deduct 0.2 from the required EER for units with a heating section other than electric resistance heat (this deduction applies for units with gas heating).

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 |
| ≥65kBtuh & <135 kBtuh | 11.0 EER | 3.3 COP |
| ≥135kBtuh & <240 kBtuh | 10.6 EER | 3.2 COP |
| ≥240kBtuh | 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.

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

### 1.5.1 Study Title #1

N/A

## 1.6 Data Quality and Future Data Needs

N/A

# Section 2. Calculation Methodology

### 2.1 Methodology

For each building type, a building scenario was created in EnergyPro and its HVAC operation was simulated for both VRF heat pump and heat recovery systems installed in office spaces in each of the SCE climate zones.

Based on interviews with large HVAC distributors, Daikin and Mitsubishi represent nearly all of the VRF equipment currently sold in California and both of these VRF manufacturers were included in the simulations. In addition, the simulations were comprised of a 50%/50% split between ducted and ductless VRF units, which is typical of the type of units installed in office spaces per the information obtained from the interviews mentioned above.

Three baseline Title 24 systems were modeled in EnergyPro. For each manufacturer and VRF system type, the energy savings were determined by subtracting the VRF annual energy use from the annual energy use of the baseline Title 24 system. The savings for each VRF manufacturer was combined via a straight average to obtain the final results per SCE climate zone (see section 2.3). The DEER peak demand reduction for each manufacturer and VRF system type was obtained for each climate zone using the values provided in the UTIL-1 form produced by the Energy Pro simulations. The demand reduction for each VRF manufacturer was combined via a straight average to obtain the final results per SCE climate zone (see section 2.3). The baseline systems and the components that comprise their total energy use are described in section 2.2.

### 2.2 Building Models and Baseline Systems

The first two building scenarios involved a 7200 sq. ft., two-story office building (small office). Interviews with HVAC distributors indicated that buildings of this size are typically served by individual single zone packaged AC units with gas heat or heat pumps. Therefore, the baseline system for the two story office was modeled with two single zone packaged AC rooftop units (RTU) with gas heat per floor for a total of four units. Each floor was divided into two zones and each zone was served by a single packaged unit. For the VRF measure scenario, each floor was divided into four zones of equal volume located in each quadrant of the building for a total of 8 zones. The first measure scenario simulated VRF heat pump units and the second simulated VRF Heat Recovery units in the building.

Similar to the first two scenarios described above, a third and fourth scenario was prepared using individual single zone packaged heat pump units for the baseline.

The fifth and sixth building scenarios involved a 41,500 sq. ft., three-story office building (large office). This was a mixed use building with individual offices, open cubicle space, conference rooms, a cafeteria, and a lobby that was comprised of approximately 48 zones. The baseline system for the three-story office was a packaged Variable Air Volume (VAV) unit with a gas boiler and hot water reheat system as defined by the Title 24 ACM. For the VRF measure model, the 48 zones were modeled similar to the basecase. The fifth measure model simulated VRF heat pump units and the sixth simulated VRF Heat Recovery units in the building.

As described in the methodology section above, the individual annual energy savings were calculated by subtracting the VRF annual energy use from the baseline energy use.

**VRF Heat Pump Savings (kWh) = Baseline Annual Energy - VRF HP Annual Energy**

**VRF Heat Recovery Savings (kWh) = Baseline Annual Energy - VRF HR Annual Energy**

where,

**Baseline Annual Energy (single zone AC unit with gas heat) = Space Cooling + Fans**

**Baseline Annual Energy (single zone heat pump) = Space Cooling + Space Heating + Fans**

**Baseline Annual Energy (for VAV unit) = Space Cooling + Fans + Circulation Pumps**

and

**VRF HP Annual Energy = Space Cooling + Space Heating + Fans**

**VRF HR Annual Energy = Space Cooling + Space Heating + Fans + Branch Controllers**

Branch controllers are used to route refrigerant between zones for heat recovery systems that can provide simultaneous heating and cooling. Please note that “Space Heating” is not included in the baseline annual energy for both single zone AC units with gas heat and the VAV unit because they do not consume electricity when in heating mode (they consume natural gas).

## 2.3 Energy Savings & Demand Reduction

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Small Office VRF Heat Pump vs Single Zone Packaged AC** | | |
|  |  |  |  |
|  | **Average Energy Savings** | **Average Demand Reduction** |  |
| **CZ** | **(kWh/ton)** | **(kW/ton)** |  |
| **6** | 1,256.60 | 0.4938 |  |
| **8** | 1,617.00 | 0.8125 |  |
| **9** | 1,796.17 | 0.8958 |  |
| **10** | 1,803.73 | 0.9115 |  |
| **13** | 1,927.08 | 1.0192 |  |
| **14** | 1,603.30 | 0.9804 |  |
| **15** | 2,438.53 | 1.0883 |  |
| **16** | 986.81 | 0.8396 |  |

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Small Office VRF Heat Recovery vs Single Zone Packaged AC** | | |
|  |  |  |  |
|  | **Average Energy Savings** | **Average Demand Reduction** |  |
| **CZ** | **(kWh/ton)** | **(kW/ton)** |  |
| **6** | 1,229.83 | 0.4833 |  |
| **8** | 1,586.83 | 0.7979 |  |
| **9** | 1,766.15 | 0.8792 |  |
| **10** | 1,786.15 | 0.9019 |  |
| **13** | 1,910.81 | 1.0096 |  |
| **14** | 1,609.95 | 0.9768 |  |
| **15** | 2,398.23 | 1.0700 |  |
| **16** | 996.96 | 0.8292 |  |

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Small Office VRF Heat Pump vs Single Zone Packaged Heat Pump** | | |
|  |  |  |  |
|  | **Average Savings** | **Average Demand Reduction** |  |
| **CZ** | **(kWh/ton)** | **(kW/ton)** |  |
| **6** | 1,263.15 | 0.4938 |  |
| **8** | 1,626.46 | 0.8125 |  |
| **9** | 1,803.58 | 0.8958 |  |
| **10** | 1,817.96 | 0.9115 |  |
| **13** | 2,009.96 | 1.0192 |  |
| **14** | 1,712.30 | 0.9804 |  |
| **15** | 2,444.57 | 1.0883 |  |
| **16** | 1,470.81 | 0.8396 |  |

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Small Office VRF Heat Recovery vs Single Zone Packaged Heat Pump** | | |
|  |  |  |  |
|  | **Average Savings** | **Average Demand Reduction** |  |
| **CZ** | **(kWh/ton)** | **(kW/ton)** |  |
| **6** | 1,236.38 | 0.4833 |  |
| **8** | 1,596.29 | 0.7979 |  |
| **9** | 1,773.56 | 0.8792 |  |
| **10** | 1,800.38 | 0.9019 |  |
| **13** | 1,993.69 | 1.0096 |  |
| **14** | 1,718.95 | 0.9768 |  |
| **15** | 2,404.27 | 1.0700 |  |
| **16** | 1,480.96 | 0.8292 |  |

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Large Office VRF Heat Pump vs Packaged VAV** | | |
|  |  |  |  |
|  | **Average Savings** | **Average Demand Reduction** |  |
| **CZ** | **(kWh/ton)** | **(kW/ton)** |  |
| **6** | 589.08 | 0.0398 |  |
| **8** | 573.69 | 0.1573 |  |
| **9** | 629.23 | 0.0464 |  |
| **10** | 498.40 | -0.0130 |  |
| **13** | 396.11 | 0.0300 |  |
| **14** | 505.25 | 0.0745 |  |
| **15** | 582.78 | 0.0531 |  |
| **16** | 349.49 | 0.1923 |  |

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Large Office VRF Heat Recovery vs Packaged VAV** | | |
|  |  |  |  |
|  | **Average Savings** | **Average Demand Reduction** |  |
| **CZ** | **(kWh/ton)** | **(kW/ton)** |  |
| **6** | 541.70 | 0.0290 |  |
| **8** | 513.98 | 0.1385 |  |
| **9** | 569.46 | 0.0234 |  |
| **10** | 443.05 | -0.0380 |  |
| **13** | 357.28 | 0.0050 |  |
| **14** | 492.59 | 0.0523 |  |
| **15** | 544.86 | 0.0456 |  |
| **16** | 364.63 | 0.1774 |  |

# 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** |
| Office – Small | New\_AC-Ret | Small\_Office |
| Office – Large | New\_AC-Ret | Large\_Office |

# Section 4. Costs

## 4.1 Base Case Cost

DEER 2011 did not provide any cost information on this type of equipment. The base case equipment costs were obtained from Energy Solutions by averaging data collected from RSMeans and interviews with HVAC contractors. Base case labor costs were taken directly from RSMeans and adjusted to a per ton basis.

Base Case Costs

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure Name** | **Base Case Equipment (Material) Cost per ton** | **Base Case Labor Cost per ton** | **RS Means 2010 Reference** |
| Title 24 baseline single-zone Packaged DX Air Conditioner with gas heating | $1,000 | $265 | 23 74 33.10 1140  5 ton cooling,  112 MBH heating |
| Title 24 baseline single-zone Packaged DX Heat Pump | $1,000 | $240 | 23 74 33.10 1310  Electic cool, electric heat  5 ton |
| Title 24 baseline multi-zone Packaged DX Variable Air Volume (VAV) Air Conditioner with gas boiler and reheat | $1,400 | $160 | 23 74 33.10 7130  Multizone, cool/heat,  Variable volume distribution, 105 ton cooling |

## 4.2 Measure Case Cost

For ROB, the equipment being replaced is assumed to have failed in place or is past its useful life. The customer is faced with either purchasing standard efficiency or code baseline equipment versus energy efficient equipment. Therefore, gross measure cost (GMC) means the cost premium required to install the energy efficient measure over a less efficient piece of equipment. GMC is represented by the equation below:

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

(Base Case Equipment Cost + Base Case Labor Cost)

= (Measure Equipment Cost – Base Case Equipment Cost)

\*Note: Unless stated otherwise the measure case labor and base case labor are assumed to be the same value.

The gross measure costs for VRF Heat Pumps and Heat Recovery Units are based on average prices that were obtained by Energy Solutions from various HVAC distributors and are shown below. These prices include labor, to determine the equipment cost, it was assumed that the measure case labor cost was the same as the base case labor cost. Table 11 shows a sample calculation of GMC; the rest of the calculations can be found in the Calculation Template [F].

Sample Gross Measure Costs

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Technology** | **Measure Name** | **Gross Measure Cost (including labor)**  **per ton** | **Gross Measure Labor Cost** | **Gross Measure Equipment Cost** | **GMC** |
| Variable Refrigerant Flow Heat Pump | Variable Refrigerant Flow Heat Pump >=65kBtuh (with packaged VAV baseline) | $2,100 | $160.00 | $1,940.00 | $540.00 |
| Variable Refrigerant Flow Heat Recovery Unit | Variable Refrigerant Flow Heat Recovery >=65kBtuh (with packaged VAV baseline) | $2,700 | $160.00 | $2,540.00 | $1,140.00 |

## 4.3 Full and Incremental Measure Cost

**Full and Incremental Measure Cost Equations**

|  |  |  |  |
| --- | --- | --- | --- |
| **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| ROB | (MEC + MLC) – (BEC + BLC) | (MEC + MLC) – (BEC + BLC) | N/A |
| NEW/NC |

MEC = Measure Equipment Cost; MLC = Measure Labor Cost

BEC = Base Case Equipment Cost; BLC = Base Case Labor Cost

**Full and Incremental Costs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure** | **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| AC-18793 | ROB | $540.00 | $540.00 | N/A |
| AC-20693 | ROB | $835.00 | $835.00 | N/A |
| AC-39286 | ROB | $860.00 | $860.00 | N/A |
| AC-49676 | ROB | $1,140.00 | $1,140.00 | N/A |
| AC-57395 | ROB | $1,435.00 | $1,435.00 | N/A |
| AC-69593 | ROB | $1,460.00 | $1,460.00 | N/A |

# Attachments

1. 
2. There are numerous EnergyPro files that were created for the calculations in this workpaper. Due to the quantity of files they have been saved to the engineering workpaper folder and are available upon request.

# References



[A] California Public Utilities Commission, 2011 Database for Energy-Efficient Resources (DEER) Version 4.01 ([www.deeresources.com](http://www.deeresources.com))

[B] EnergySoft, LLC, EnergyPro 5.1.3.0, Title 24 Performance Compliance Module (www.energysoft.com), Copyright 2010

[C] EnergySoft, LLC, Application for the Adoption of Variable Refrigerant Flow Systems under the Title 24-2005 Nonresidential ACM Procedures, July 2008

[D] California Energy Commission, Title 20 2009 Appliance Efficiency Regulations, Section 1605.1 (c), page 136, August 2009

[E] Dodd, Martyn, EnergySoft, LLC, Building models, data analysis, and work paper

methodology review, April 2010

[F] Attachment 1 – Calculation Template v2.2.xlsm