CPUC Ex-Ante Team

Contents

[1 Overview 2](#_Toc476141779)

[2 Development of Savings Values 2](#_Toc476141780)

[2.1 VRF Measure Technology Definitions 2](#_Toc476141781)

[2.1.1 Measure Tier Levels 2](#_Toc476141782)

[2.1.2 Minimum IEER Requirements 2](#_Toc476141783)

[2.2 DEER Prototypes 5](#_Toc476141784)

[2.3 Same-Technology Baseline Definitions 5](#_Toc476141785)

[2.4 Alternate-Technology Baseline Definitions 6](#_Toc476141786)

[2.4.1 All-Electric Baselines (Title-24) 6](#_Toc476141787)

[2.4.2 Fuel Heat Baselines (Title-24) 7](#_Toc476141788)

[2.4.3 Fuel Heat Baselines (High Performance) 9](#_Toc476141789)

[3 Results 10](#_Toc476141790)

[3.1 All-Electric Scenarios 10](#_Toc476141791)

[3.2 Fuel-Switching Scenarios 27](#_Toc476141792)

[3.2.1 Energy Impacts 27](#_Toc476141793)

[3.2.2 Three Prong Test 36](#_Toc476141794)

# Overview

This document provides a summary of simulations that were performed to support the development of variable refrigerant flow (VRF) measures. Representative DEER building prototype models were utilized for four building types with a range of baselines that include both conventional systems and variable refrigerant flow systems. Simulations were performed using the latest version of DOE-2.3, which has expanded capabilities to enable accurate modeling of VRF systems. Additional details regarding the development of the baselines and technologies can be found in the CPUC VRF Assessment Report[[1]](#footnote-2).

# Development of Savings Values

All measure and baseline energy models used for these simulations were developed from the DEER prototype definitions. The VRF measure technologies were modeled by converting the systems in the DEER packaged heat pump prototype model to multizone VRF systems. The VRF technologies were then compared to several different baselines, which included both all-electric and fuel baselines, to develop savings values. For the fuel baselines, additional simulations were run to satisfy the "Three Pronged Test" requirement that proposed technologies must be compared with the most efficient cost-effective same-fuel substitute technologies.

## VRF Measure Technology Definitions

### Measure Tier Levels

Measure technologies were developed based on VRF system size as shown in Table 1. The outdoor unit efficiency is the only parameter that changed between the VRF baselines and the VRF measures.

Table 1 VRF Measure Levels vs System Capacity

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | System | AHRI Rated EER | | |
| Building Type | Tons | Title 24 | Tier 1 | Tier 2 |
| Hotel Guest Room | 8 | 11.0 | 13.0 | 15.0 |
| Small Office | 14 | 10.6 | 12.0 | 13.5 |
| Primary School, Hotel Public Areas | 18 | 10.6 | 12.0 | 13.5 |
| Large Office | 20 | 9.5 | 11.5 | 13.0 |

### Minimum IEER Requirements

The method for the use of IEER values in the selection of measure tier is based on the method developed in DEER 2017 for packaged air conditioners and heat pumps[[2]](#footnote-3). For each efficiency tier level, a minimum IEER value has been determined by review of market data available in the AHRI database[[3]](#footnote-4), as shown in Figure 1 to Figure 3.



Figure 1 Relationship between Rated IEER and Rated EER for VRF Units 65 to 135 kBtu/hr (AHRI Database)



Figure 2 Relationship between Rated IEER and Rated EER for VRF Units 135 to 240 kBtu/hr (AHRI Database)



Figure 3 Relationship between Rated IEER and Rated EER for VRF Units 240 kBtu/hr and larger (AHRI Database)

For a given VRF system, the manufacture will specify both a rated EER and a rated IEER, based on AHRI requirements. The selection of tier level must be based on both of these parameters, while any interpolation between Ex Ante tiers must be based solely on the rated EER. If the rated EER and the rated IEER are both greater than or equal to the tier level values, then that tier is valid. It is not acceptable to move to the next tier if the rated IEER satisfies the minimum IEER threshold of the tier but the rated EER for the equipment does not satisfy the EER requirement for the tier. Interpolations can be performed between two Ex Ante tier levels based on EER, but not IEER, and only if the IEER for the equipment meets the interpolated minimum IEER threshold. The two examples in the table below show units with the same rated EER value and with differing IEER values that both resolve to using the same Ex Ante savings value developed for an interpolation between the two bounding Ex Ante measures using the unit rated EER value.

Table 2 Sample Selection of Ex Ante Values Based on EER and IEER

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Equip EER | Equip IEER | Tier Below EER/ min IEER | Tier Above EER/ min IEER | Selected Tier EER |
| 13.5 | 22 | 13.0/20.0 | 15.0/22.0 | 13.0 |
| 13.5 | 23 | 13.0/20.0 | 15.0/22.0 | 13.0 |

Table 3 below provides EER and IEER minimum values required to be met for code compliance as well as to qualify for savings at the various Ex Ante tier levels of performance. As noted above to qualify for savings treatment at a tier level both the minimum EER and IEER requirements must be met. Interpolation between tiers is performed using EER values only.

Table 3 EER and IEER Code and Tier Minimum Values for VRF Systems

|  |  |  |
| --- | --- | --- |
| Capacity of 65 to <135 kBtu/hr | | |
| Tier | Minimum Rated EER | Minimum Rated IEER |
| Code | 11 | 12.9 |
| 1 | 13 | 20 |
| 2 | 15 | 22 |
| Capacity of 135 to <240 kBtu/hr | | |
| Tier | Minimum Rated EER | Minimum Rated IEER |
| Code | 10.6 | 12.3 |
| 1 | 12 | 18 |
| 2 | 13.5 | 19.5 |
| Capacity of <=240 kBtu/hr | | |
| Tier | Minimum Rated EER | Minimum Rated IEER |
| Code | 9.5 | 11.0 |
| 1 | 11.5 | 18.5 |
| 2 | 13 | 21 |

## DEER Prototypes

The building models utilized for the VRF technology simulations were derived from the DEER 2015 prototypes[[4]](#footnote-5). Four building types were included in the assessment, as shown in Table 4.

Table 4 DEER Prototypes for VRF Measure Development



Since the analysis was performed using the DOE-2.3 building modeling software, some minor changes were needed to make the DEER 2015 models compatible with the program. Moreover, the small office model was updated with a change from interior air-walls to interior mass walls in order to provide more realistic isolation of core and perimeter zones for the VRF heat recovery system analysis. Additional changes to the DEER prototypes are described in the Baseline Definitions section of this report.

## Same-Technology Baseline Definitions

A set of Ex Ante measures has been developed for VRF systems using baselines that have a minimally compliant version of the same type of VRF technology as the measure, as shown in Table 5. The only change between the baseline technology and the measure technology for each of these measures is the system efficiency, which was listed previously for each technology in Table 1.

Table 5 Ex Ante Measures with Same-Technology Baselines

|  |  |
| --- | --- |
| Measure | Baseline |
| Heat Pump VRF System, Tier 1 | Heat Pump VRF System, Title-24 |
| Heat Pump VRF System, Tier 2 | Heat Pump VRF System, Title-24 |
| Heat Recovery VRF System, Tier 1 | Heat Recovery VRF System, Title-24 |
| Heat Recovery VRF System, Tier 2 | Heat Recovery VRF System, Title-24 |

## Alternate-Technology Baseline Definitions

Several different alternate-technology baselines were evaluated in order to demonstrate the relative performance of VRF technologies compared to non-VRF systems, as shown in Table 6. If it can be demonstrated that VRF systems are installed in as a substitute for one of these baseline technologies, then this assessment can be used to determine impacts.

Table 6 Alternate-Technology Baselines for VRF Measures

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | Building Type Applicability | | | |
|  |  | Small Office | Primary School | Large Office | Hotel |
| All Electric Title-24 Baselines | |  |  |  |  |
| 1. | Packaged single zone heat pump, (< 65 kBtuh) without economizer | X | X | X |  |
| 2. | Packaged single zone heat pump, (< 65 kBtuh) with economizer | X | X | X | X |
| 3. | Packaged single zone heat pump, (65 to 135 kBtuh), with economizer | X | X | X | X |
| Fuel Heat Title-24 Baselines | |  |  |  |  |
| 1. | Packaged single zone AC/furnace, (< 65 kBtuh) without economizer | X | X |  |  |
| 2. | Packaged single zone AC/furnace, (< 65 kBtuh) with economizer | X | X |  |  |
| 3. | Packaged single zone AC/furnace, (65 to 135 kBtuh), with economizer | X | X |  |  |
| 4. | Packaged variable air volume AC/ gas boiler, with economizer | X | X |  |  |
| 5. | Four pipe fan coil system with water-cooled chiller and gas boiler |  |  | X | X |
| Fuel Heat High Performance Baselines (for Three-Prong Test) | |  |  |  |  |
| 1. | Packaged single zone AC/furnace, (< 65 kBtuh) with economizer | X | X |  |  |
| 2. | Packaged single zone AC/furnace, (65 to 135 kBtuh), with economizer | X | X |  |  |
| 3. | Packaged variable air volume AC/ gas boiler, with economizer | X | X |  |  |
| 4. | Four pipe fan coil system with water-cooled chiller and gas boiler |  |  | X | X |

### All-Electric Baselines (Title-24)

Key parameters for each of the all-electric baselines are listed below.

1. Packaged single zone heat pump with economizer (<65 kBtuh)

* SEER 14, HSPF 7.7 (hotel guest room: EER 10.7, COP 3.1)
* One speed fan
* Fan power 0.294 W/cfm (hotel guest room: 0.125 W/cfm)
* No economizer

1. Packaged single zone heat pump without economizer (<65 kBtuh)

* SEER 14, HSPF 7.7 (hotel guest room: EER 10.7, COP 3.1)
* One speed fan
* Fan power 0.294 W/cfm (hotel guest room: 0.125 W/cfm)
* Air economizer (except hotel guest room)

1. Packaged single zone heat pump with economizer (65 to 135 kBtuh)

* EER 10.8, COP 3.3 (hotel guest room: EER 10.7, COP 3.1)
* Two speed fan
* Fan power 0.4 W/cfm (hotel guest room: 0.125 W/cfm)
* Air economizer (except hotel guest room)

The conventional heat pump alternates included in this assessment are identical to those used for the DEER 2015 release, except for the following changes:

1. A problem was found in the bypass factor performance curves in the DEER 2015 heat pump simulations. This was resolved by changing to the default bypass factor curves from the DOE2 library.
2. One significant change from DEER2015 relates to frost control of the heat pump outdoor coil during heating mode. Defrost heat for the conventional heat pumps was provided by the unit operating in a reverse cycle (DEER2015 assumed electric resistance). Moreover, the assumed defrost control scenario operates on a cycling period and defrost run time that are both based on demand (DEER2015 assumed a time initiated/temperature terminated control). In addition, the DOE2 algorithm for frost control for conventional heat pumps was updated for DOE2.3. The details of this update are summarized in the CPUC VRF assessment report.
3. One minor control change for heat pump operation relates to the temperature above which supplementary electric resistance heat was disabled. In DEER2015, this value was defaulted to 40°F, but this resulted in some hours with insufficient heating capacity. For the current assessment, the value has been changed to 52°F. The DOE-2.3 model gives the heat pump cycle first priority as long as it is enabled, and only allows the electric resistance heat to provide additional capacity when the heat pump is running at 100%.
4. Heat pumps measures were not updated in DEER 2015 for systems in the 65 to 135 kBtuh range, so DEER 2014[[5]](#footnote-6) was used as the source for these baselines. The heating performance curves from DEER 2014 did not account for changes in air temperature entering the indoor coil, and this was resulting in unreasonable heating energy calculations. To resolve this, heat pump performance curves from DEER 2015 for the 2 speed heat pumps in the 0 to 65 kBtuh category were utilized.

### Fuel Heat Baselines (Title-24)

Key parameters for each of the baselines with fuel heat are listed below.

1. Packaged single zone air conditioner with economizer (<65 kBtuh)

* SEER 14, Furnace 80%
* One speed fan
* Fan power 0.294 W/cfm
* No economizer

1. Packaged single zone air conditioner without economizer (<65 kBtuh)

* SEER 14, Furnace 80%
* One speed fan
* Fan power 0.294 W/cfm
* Air economizer

1. Packaged single zone air conditioner with economizer (65 to 135 kBtuh)

* EER 10.8, Furnace 80%
* Two speed fan
* Fan power 0.4 W/cfm
* Air economizer

1. Packaged VAV with gas boiler

* EER 10.0, Boiler 80%
* Variable speed fan
* Fan power 0.72 W/cfm
* Air economizer

1. Four pipe fan coil with water cooled chiller and gas boiler

* Chiller 0.56 kW/ton
* Boiler 80% efficiency
* Two speed fans, except hotel guest rooms are one speed
* Fan power same as VRF (Table 7)
* Dedicated outside air system with 0.32 W/cfm fan power
* No economizer

Table Fan Power for Indoor Unit Terminals



### Fuel Heat Baselines (High Performance)

The Three Prong Test for fuel switching requires comparison with the best cost-effective non-fuel switched technology. Key parameters for each of these high performance fuel heat baselines are listed below.

1. Packaged single zone air conditioner with economizer (<65 kBtuh)

* SEER 18, Furnace 80%
* Two speed fan
* Fan power 0.271 W/cfm
* Air economizer

1. Packaged single zone air conditioner with economizer (65 to 135 kBtuh)

* EER 13, Furnace 80%
* Two speed fan
* Fan power 0.4 W/cfm
* Air economizer

1. Packaged VAV with gas boiler

* EER 12.5, Condensing Boiler 95%
* Variable speed fan
* Fan power 0.72 W/cfm
* Air economizer

1. Four pipe fan coil with water cooled chiller and gas boiler

* Chiller 0.476 kW/ton
* Condensing Boiler 95% efficiency
* Two speed fans, except hotel guest rooms are one speed
* Fan power same as VRF (Table 7)
* Dedicated outside air system with 0.32 W/cfm fan power
* No economizer

# Results

## All-Electric Scenarios

Annual energy and peak period energy impacts for the all-electric scenarios in Vintage 2014 are shown graphically in Figure 4 through Figure 19.

Tabulated technology energy results are provided in the workbook VRF\_HP\_Results\_All.xlsx.

|  |  |
| --- | --- |
| Baseline is One Speed  T-24 Packaged Heat Pump,  < 65 kBtuh,  with economizer |  |
| Baseline is One Speed  T-24 Packaged Heat Pump,  < 65 kBtuh,  without economizer |  |
| Baseline is 2 Speed T-24 Packaged Heat Pump,  65-135 kBtuh,  with economizer |  |

Figure 4 Annual Energy Savings Relative to Conventional Heat Pump, Vintage 2014, Small Office

|  |  |
| --- | --- |
| Baseline is T-24 Heat Pump VRF System |  |
| Baseline is T-24 Heat Recovery VRF System |  |

Figure 5 Annual Energy Savings Relative to Title-24 VRF System, Vintage 2014, Small Office

|  |  |
| --- | --- |
| Baseline is One Speed  T-24 Packaged Heat Pump,  < 65 kBtuh,  with economizer |  |
| Baseline is One Speed  T-24 Packaged Heat Pump,  < 65 kBtuh,  without economizer |  |
| Baseline is 2 Speed  T-24 Packaged Heat Pump,  65-135 kBtuh,  with economizer |  |

Figure 6 Peak Period kW Savings Relative to Conventional Heat Pump, Vintage 2014, Small Office

|  |  |
| --- | --- |
| Baseline is T-24 Heat Pump VRF System |  |
| Baseline is T-24 Heat Recovery VRF System |  |

Figure 7 Peak Period kW Savings Relative to Title-24 VRF System, Vintage 2014, Small Office

|  |  |
| --- | --- |
| Baseline is One Speed  T-24 Packaged Heat Pump,  < 65 kBtuh,  with economizer |  |
| Baseline is One Speed  T-24 Packaged Heat Pump,  < 65 kBtuh,  without economizer |  |
| Baseline is 2 Speed T-24 Packaged Heat Pump,  65-135 kBtuh,  with economizer |  |

Figure 8 Annual Energy Savings Relative to Conventional Heat Pump, Vintage 2014, Large Office

|  |  |
| --- | --- |
| Baseline is T-24 Heat Pump VRF System |  |
| Baseline is T-24 Heat Recovery VRF System |  |

Figure 9 Annual Energy Savings Relative to Title-24 VRF System, Vintage 2014, Large Office

|  |  |
| --- | --- |
| Baseline is One Speed  T-24 Packaged Heat Pump,  < 65 kBtuh,  with economizer |  |
| Baseline is One Speed  T-24 Packaged Heat Pump,  < 65 kBtuh,  without economizer |  |
| Baseline is 2 Speed T-24 Packaged Heat Pump,  65-135 kBtuh,  with economizer |  |

Figure 10 Peak Period kW Savings Relative to Conventional Heat Pump, Vintage 2014, Large Office

|  |  |
| --- | --- |
| Baseline is T-24 Heat Pump VRF System |  |
| Baseline is T-24 Heat Recovery VRF System |  |

Figure 11 Peak Period kW Savings Relative to Title-24 VRF System, Vintage 2014, Large Office

|  |  |
| --- | --- |
| Baseline is One Speed  T-24 Packaged Heat Pump,  < 65 kBtuh,  with economizer |  |
| Baseline is One Speed  T-24 Packaged Heat Pump,  < 65 kBtuh,  without economizer |  |
| Baseline is 2 Speed T-24 Packaged Heat Pump,  65-135 kBtuh,  with economizer |  |

Figure 12 Annual Energy Savings Relative to Conventional Heat Pump, Vintage 2014, Primary School

|  |  |
| --- | --- |
| Baseline is T-24 Heat Pump VRF System |  |
| Baseline is T-24 Heat Recovery VRF System |  |

Figure 13 Annual Energy Savings Relative to Title-24 VRF System, Vintage 2014, Primary School

|  |  |
| --- | --- |
| Baseline is One Speed  T-24 Packaged Heat Pump,  < 65 kBtuh,  with economizer |  |
| Baseline is One Speed  T-24 Packaged Heat Pump,  < 65 kBtuh,  without economizer |  |
| Baseline is 2 Speed T-24 Packaged Heat Pump,  65-135 kBtuh,  with economizer |  |

Figure 14 Peak Period kW Savings Relative to Conventional Heat Pump, Vintage 2014, Primary School

|  |  |
| --- | --- |
| Baseline is T-24 Heat Pump VRF System |  |
| Baseline is T-24 Heat Recovery VRF System |  |

Figure 15 Peak Period kW Savings Relative to Title-24 VRF System, Vintage 2014, Primary School

|  |  |
| --- | --- |
| Baseline is One Speed  T-24 Packaged Heat Pump,  < 65 kBtuh,  with economizer |  |
| Baseline is One Speed  T-24 Packaged Heat Pump,  < 65 kBtuh,  without economizer |  |
| Baseline is 2 Speed T-24 Packaged Heat Pump,  65-135 kBtuh,  with economizer |  |

Figure 16 Annual Energy Savings Relative to Conventional Heat Pump, Vintage 2014, Hotel

|  |  |
| --- | --- |
| Baseline is T-24 Heat Pump VRF System |  |
| Baseline is T-24 Heat Recovery VRF System |  |

Figure 17 Annual Energy Savings Relative to Title-24 VRF System, Vintage 2014, Hotel

|  |  |
| --- | --- |
| Baseline is One Speed  T-24 Packaged Heat Pump,  < 65 kBtuh,  with economizer |  |
| Baseline is One Speed  T-24 Packaged Heat Pump,  < 65 kBtuh,  without economizer |  |
| Baseline is 2 Speed T-24 Packaged Heat Pump,  65-135 kBtuh,  with economizer |  |

Figure 18 Peak Period kW Savings Relative to Conventional Heat Pump, Vintage 2014, Hotel

|  |  |
| --- | --- |
| Baseline is T-24 Heat Pump VRF System |  |
| Baseline is T-24 Heat Recovery VRF System |  |

Figure 19 Peak Period kW Savings Relative to Title-24 VRF System, Vintage 2014, Hotel

## Fuel-Switching Scenarios

### Energy Impacts

Annual energy and peak period energy results for the fuel switching scenarios in Vintage 2014 are shown in Figure 20 through Figure 27. Impacts are calculated per ton of installed capacity from the measure technology simulation. Tabulated technology energy results are provided in the workbook VRF\_HP\_Results\_All.xlsx.

|  |  |
| --- | --- |
| Baseline is One Speed T-24 Packaged AC/furnace, < 65 kBtuh,  with economizer |  |
| Baseline is One Speed T-24 Packaged AC/furnace, < 65 kBtuh,  without economizer |  |
| Baseline is 2 Speed T-24 Packaged AC/furnace,  65-135 kBtuh, with economizer |  |
| Baseline is T-24 Packaged Variable Air Volume system with gas boiler and economizer |  |

Figure 20 Annual Electric Energy Savings vs. AC/Gas Heat, Vintage 2014, Small Office

|  |  |
| --- | --- |
| Baseline is One Speed T-24 Packaged AC/furnace, < 65 kBtuh,  with economizer |  |
| Baseline is One Speed T-24 Packaged AC/furnace, < 65 kBtuh,  without economizer |  |
| Baseline is 2 Speed T-24 Packaged AC/furnace,  65-135 kBtuh, with economizer |  |
| Baseline is T-24 Packaged Variable Air Volume system with gas boiler and economizer |  |

Figure 21 Annual Electric Demand Savings vs. AC/Gas Heat, Vintage 2014, Small Office

|  |  |
| --- | --- |
| Baseline is One Speed T-24 Packaged AC/furnace, < 65 kBtuh,  with economizer |  |
| Baseline is One Speed T-24 Packaged AC/furnace, < 65 kBtuh,  without economizer |  |
| Baseline is 2 Speed T-24 Packaged AC/furnace,  65-135 kBtuh, with economizer |  |
| Baseline is T-24 Packaged Variable Air Volume system with gas boiler and economizer |  |

Figure 22 Annual Gas Therm Savings vs. AC/Gas Heat, Vintage 2014, Small Office

|  |  |
| --- | --- |
| Baseline is One Speed T-24 Packaged AC/furnace, < 65 kBtuh,  with economizer |  |
| Baseline is One Speed T-24 Packaged AC/furnace, < 65 kBtuh,  without economizer |  |
| Baseline is 2 Speed T-24 Packaged AC/furnace,  65-135 kBtuh, with economizer |  |
| Baseline is T-24 Packaged Variable Air Volume system with gas boiler and economizer |  |

Figure 23 Annual Electric Energy Savings vs. AC/Gas Heat, Vintage 2014, Primary School

|  |  |
| --- | --- |
| Baseline is One Speed T-24 Packaged AC/furnace, < 65 kBtuh,  with economizer |  |
| Baseline is One Speed T-24 Packaged AC/furnace, < 65 kBtuh,  without economizer |  |
| Baseline is 2 Speed T-24 Packaged AC/furnace,  65-135 kBtuh, with economizer |  |
| Baseline is T-24 Packaged Variable Air Volume system with gas boiler and economizer |  |

Figure 24 Annual Electric Demand Savings vs. AC/Gas Heat, Vintage 2014, Primary School

|  |  |
| --- | --- |
| Baseline is One Speed T-24 Packaged AC/furnace, < 65 kBtuh,  with economizer |  |
| Baseline is One Speed T-24 Packaged AC/furnace, < 65 kBtuh,  without economizer |  |
| Baseline is 2 Speed T-24 Packaged AC/furnace,  65-135 kBtuh, with economizer |  |
| Baseline is T-24 Packaged Variable Air Volume system with gas boiler and economizer |  |

Figure 25 Annual Gas Therm Savings vs. AC/Gas Heat, Vintage 2014, Primary School

|  |  |
| --- | --- |
| Annual Electric Savings |  |
| Peak Demand Savings |  |
| Annual Therm Savings |  |

Figure 26 Annual Savings vs. Four Pipe Fan Coil with Chiller and Boiler, Vintage 2014, Large Office

|  |  |
| --- | --- |
| Annual Electric Savings |  |
| Peak Demand Savings |  |
| Annual Therm Savings |  |

Figure 27 Annual Savings vs. Four Pipe Fan Coil with Chiller and Boiler, Vintage 2014, Hotel

### Three Prong Test

Any VRF measure that has a baseline with fuel heat must satisfy the CPUC three-prong test. The CPUC three-prong test for fuel-substitution programs requires that the proposed technology not increase source BTU consumption as calculated using the current CEC-established heat rate. The latest value for the heat rate is 7,760 Btu/kWh, and the following formula is used to calculate the source energy:

Source Energy = [Building Site Electric kWh] X [7,760 Btu/kWh] + [Building Site Fuel Btu]

When calculating the source energy impact, the technology offered by a program must be compared with the most efficient cost-effective technology available that uses the fuel that is to be substituted with electricity. Cost-effectiveness is defined as having a TRC and PAC benefit-cost ratio of 1.0 or greater.

Source energy impacts are presented in Figure 28 through Figure 31.

|  |  |
| --- | --- |
| Baseline is Two Speed Packaged AC/furnace, < 65 kBtuh, SEER 18, with economizer |  |
| Baseline is Two Speed Packaged AC/furnace, 65 to 135 kBtuh, EER13, with economizer |  |
| Baseline is Packaged Variable Air Volume system, EER 12.5 with economizer and 95% efficiency gas boiler |  |

Figure 28 Annual Source Energy Savings vs. Gas Heat Baselines, Vintage 2014, Small Office

|  |  |
| --- | --- |
| Baseline is Two Speed Packaged AC/furnace, < 65 kBtuh, SEER 18, with economizer |  |
| Baseline is Two Speed Packaged AC/furnace, 65 to 135 kBtuh, EER13, with economizer |  |
| Baseline is Packaged Variable Air Volume system, EER 12.5 with economizer and 95% efficiency gas boiler |  |

Figure 29 Annual Source Energy Savings vs. Gas Het Baselines, Vintage 2014, Primary School



Figure 30 Annual Source Energy Savings vs. Four Pipe Fan Coil with Water Cooled Chiller and Gas Boiler, Vintage 2014, Large Office



Figure 31 Annual Source Energy Savings vs. Four Pipe Fan Coil with Water Cooled Chiller and Gas Boiler, Vintage 2014, Hotel

1. “Variable Refrigerant Flow Performance Assessment for Typical Commercial Building in California Climates”, CPUC Ex-Ante Review Team, February 2017 [↑](#footnote-ref-2)
2. http://www.deeresources.com/files/DEER2017/download/E-4795\_2016-08-16\_Attachment.pdf [↑](#footnote-ref-3)
3. www.ahridirectory.org (Select "VRF Multi-Split Air Conditioning and Heat Pump Equipment" from COMMERCIAL") [↑](#footnote-ref-4)
4. http://www.deeresources.com/index.php/deer-versions/deer2015-code-update [↑](#footnote-ref-5)
5. http://www.deeresources.com/index.php/deer-versions/deer2013-update-for-2014-codes [↑](#footnote-ref-6)