**Work Paper Abstract**

**Product Category**

**Revision # N**

**California Technical Forum**

**WP Abstract Prepared by: Clearesult**

**Variable Refrigerant Flow**

***Abstract***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| WP Abstract Tracking Log | | | | |
| Task | **Date Issued** | **Due By** | **Version** | **Author Last Name**  **(or primary editor)** |
| Submitted to TF Staff for review |  |  |  |  |
| TF Staff sent to TF Members for 10-day review |  |  |  |  |
| Abstract presented at meeting |  |  |  |  |
| Cal TF Staff summarizes comments, sends back to abstract developer |  |  |  |  |
| Abstract developer incorporates TF comments into abstract, sends back to TF Staff |  |  |  |  |
| Abstract presented to Subcommittee (if applicable) |  |  |  |  |
| TF Staff summarizes TF Subcommittee recommendations, sends back to abstract developer |  |  |  |  |
| Abstract developer incorporates TF Subcommittee comments into abstract, sends back to TF Staff |  |  |  |  |
| TF Staff sends abstract to Commission staff for 10-day review |  |  |  |  |
| Comments from Commission staff received (if applicable) |  |  |  |  |
| Cal TF summarizes comments |  |  |  |  |
| Abstract presented at Meeting; consensus decision-marking |  |  |  |  |
| Cal TF finalizes abstract; prepares comparison exhibit of non-consensus items |  |  |  |  |
| Abstract to TF Subcommittee |  |  |  |  |
| Abstract to TF Subcommittee |  |  |  |  |
|  |  |  |  |  |
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Table 1 Work Paper Abstract Snapshot

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| --- | --- | --- |
| Work Paper Abstract Snapshot | | |
| Item | **Details** | **Notes** |
| Measure name | Variable Refrigerant Flow |  |
| Measure description | Replace existing VAV systems, rooftop packaged air conditioners and heat pumps with Variable Refrigerant Flow units with or without heat recovery. |  |
| Sector (Res/Non-Res) | Non-res |  |
| Subsector (e.g. Ag) |  |  |
| Delivery Channel (e.g. Upstream) | Upstream deemed |  |
| Measure Application Type (e.g. ROB) | NEW, ROB |  |
|  |  |  |
|  |  |  |

1. Measure Description & Key Terms

Variable Refrigerant Flow systems can replace conventional 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.

1. Program Implementation Method

Rebates are offered to distributors of VAV systems for installation in the following scenarios:

* New construction of non-residential buildings
* Replacement of existing unitary or split-system AC or HP equipment or VAV systems in non-residential buildings

The Program Restrictions and Guidelines include the following:

* 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. Mixed Baseline

The baseline includes the following four cases:

* Packaged single zone DX w/ gas furnace
* Packaged single zone heat pump
* Multi-zone VAV w/ DX cooling and HW reheat
* Multi-zone VAV w/ DX cooling and electric resistance reheat

1. Measure Summary

Table 2 Measure Summary

|  |  |
| --- | --- |
| **Characteristic** | **Measure** |
| Baseline Technology or Mix |  |
| Measure Technology |  |
| Measure Application Type | ROB, NEW |
| Delivery Mechanism | Upstream |
| Impacted Markets | Small Office, Medium Office, Education - Primary |
| Relevant Codes and Standards | T20, T24, federal standard |

1. Estimated Size of Offer (Number of Participants)

According to LG (2011), currently VRF has only a 3% share of the North American AC market. VRF has a large market potential.

According to DNV-GL’s Upstream HVAC Evaluation Draft Reserch Plan, PG&E and SCE upstream program claimed 4.2 MW, 11 GWh for VRF AC/HP systems during 2013-14 program cycles.

1. Estimated Impact of the Measure on Statewide Energy Efficiency Savings.

*Values should be developed with levels of precision and accuracy commensurate with their overall programmatic impact.*

1. Applicable DEER & CPUC Guidance

Baseline data collection

* Simulation prototypes from California Building Energy Code Compliance (CBECC)
* Baseline HVAC system and operations details from DEER

Baseline methodology

* Modify CBECC EnergyPlus prototypes to align with DEER
  + NEW: Modify HVAC system and operational parameters in CBECC prototypes to match DEER new building prototypes
  + ROB: From the NEW prototype, further modify LPD and envelope performance characteristics to match DEER 2003 vintage
* Simulate base case using EnergyPlus, weather from CZ2010
* Compare resultant base case EUIs to DEER EUIs

CPUC provided the following feedback on the preliminary simulations and proposed methodology

* 

1. Proposed Measure Parameter Values, Methodology, and Data Sources

Energy impacts are based on preliminary simulation work and should not be considered final or reliable. Range of energy impacts represents simulation of VRF heat pump in CZ13 and VRF heat pump w/ heat recovery in CZ03.

Table 3 Proposed Measure Parameter Methods, Data, Assumptions and Sources

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Measure Parameter** | **Proposed Value** | **Methodology Description** | **Key Assumptions** | **Data Source Name and Description[[1]](#footnote-1)** | **Input Requested from TF** | **Confidence Level**  **(High, Medium, Low)** |
| Baseline Energy  kWh/yr |  |  |  |  |  |  |
| Measure Energy  kWh/yr |  |  |  |  |  |  |
| Savings – kWh/yr | 275 – 588 |  |  |  |  | Low |
| Baseline Demand  kW/yr |  |  |  |  |  |  |
| Measure Demand  kW/yr |  |  |  |  |  |  |
| Savings – kW/yr | 0.07 – 0.24 |  |  |  |  | Low |
| Baseline Energy  Therms/yr |  |  |  |  |  |  |
| Measure Energy  Therms/Yr |  |  |  |  |  |  |
| Savings – therms/yr | 8.58 – 9.21 |  |  |  |  | Low |
| EUL or RUL | 15 |  |  | DEER 2008, “Air Conditioners / Heat Pumps (split and unitary),” from updated EUL\_Summary\_10-1-08 |  | Med |
| IMC | $547 |  |  | Cost survey of 4 distributors, 2 manufacturers, and one contractor engineer |  | Med |
| NTG | 0.89 |  |  | DEER 2011, “All package and split system AC & HP replacements.” |  | Med |

1. Proposed Level of Complexity

*Indicate the suggested level of methodological complexity if multiple options exist, including a description of the impact on UES accuracy and/or precision. Explanation should consider cost of development, size of offer, potential portfolio impact, etc. For example, if the UES can be calculated using either engineering calculations or building energy simulation software, indicate which method is preferred and why.*

1. Preliminary TRC Estimates

Table 4 Preliminary TRC Estimates and Parameters

|  |  |  |  |
| --- | --- | --- | --- |
| **TRC Parameter** | **Parameter Estimate or**  **Required Parameter Value Threshold** (specify if estimate or threshold) | **Confidence Level**  **(High, Medium, Low)** | **Comments** |
| UES | 275-588 kWh/ton | Low |  |
| IMC | $547 | Med |  |
| EUL | 15 | Med |  |
| NTG | 0.89 | Med |  |
| Incentive/unit | TBD |  |  |
| Number of units | 450-900 | Med |  |
| Installation Rate | 1 | Low |  |
| Gross Realization Rate | 1 | Low |  |
|  |  |  |  |
|  |  |  |  |
| ***TRC Value:*** | **Estimated 1.1 – 2.1** | | |

1. Literature Review

*Description of research performed to develop this abstract, including:*

* *Market assessment: what does the market for this measure currently look like, and where is it going?*
* *Relevant EM&V studies*
* *Measure offering in other jurisdictions*
* *Sources considered for this abstract/workpaper but not used, and reasons why*

*Please include page citations when appropriate.*

1. Additional Research Needed

Areas of uncertainty that need additional attention:

1. **Measure**. Concern that design and installation characteristics necessary to achieve the estimated performance are not likely to be achieved in actual practice
2. **Baseline**. Different system configuration and operation from measure
3. **Fuel Substitution**. Ex-ante consultants do not accept the proposed baseline system for the three-prong test as representing the required most efficient, same fuel, technology.
4. **EnergyPlus**. Concern that additional testing and verification is needed to ensure results for EnergyPlus as used to represent typical expected comparative energy use results for VRF and non-VRF systems are reasonable.
5. Questions for CPUC Staff on Applicability of DEER Values, Methods, Tools, Data, Etc.

* What are appropriate base case systems?
* How should we deal with the difference between ventilation systems?
* Is the EnergyPlus VRF module sufficiently accurate? If unknown, then what criteria should we use to test?
* Should other VRF benefits, such as reduced duct area, be included in the cost analysis?

1. Cal TF Comments on Proposed Measure Parameter Values, Methodology, and Data Sources

*Cal TF comments on proposed data and sources. Do data represent best available data? If not, what are alternate data/sources that should be considered?*

Table 5 Cal TF Comments on Measure Parameter Methods, Data, Assumptions, and Sources

|  |  |
| --- | --- |
| **Measure Parameter** | **Cal TF Comments / Recommendations** |
| Baseline Energy  kWh/yr |  |
| Measure Energy  kWh/yr |  |
| Savings – kWh/yr |  |
| Baseline Demand  kW/yr |  |
| Measure Demand  kW/yr |  |
| Savings – kW/yr |  |
| Baseline Energy  Therms/yr |  |
| Measure Energy  Therms/Yr |  |
| Savings – therms/yr |  |
| EUL or RUL |  |
| MC or IMC |  |
| NTG |  |

1. Cal TF Comments on Proposed Level of Complexity

*Cal TF comments on proposed level of complexity based on input from abstract developer and Cal TF discussion.*

1. Other Cal TF Comments
2. Commission Staff Review and Feedback

*Commission staff should provide feedback on proposed data and sources within 10 days of request.*

Table 7 Commission Staff Feedback on Proposed Data and Sources

|  |  |
| --- | --- |
| **Measure Parameter** | **Commission Staff Comments / Recommendations** |
| Baseline Energy  kWh/yr |  |
| Measure Energy  kWh/yr |  |
| Savings – kWh/yr |  |
| Baseline Demand  kW/yr |  |
| Measure Demand  kW/yr |  |
| Savings – kW/yr |  |
| Baseline Energy  Therms/yr |  |
| Measure Energy  Therms/Yr |  |
| Savings – therms/yr |  |
| EUL or RUL |  |
| MC or IMC |  |
| NTG |  |

# Appendix A – Sources

List all source links or embedded documents (reference relevant page number as appropriate)

1. Provide a link to source or embed source in Appendix A of this document with page numbers specified. [↑](#footnote-ref-1)