Utility Program Cost Effectiveness of Variable Refrigerant Flow Systems

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ABSTRACT

Variable Refrigerant Flow (VRF) systems are gaining popularity as a means of providing energy-efficient heating and cooling in buildings. Though research is limited, it is generally understood that these systems deliver energy savings, and utilities and other energy efficiency program implementers are looking to provide incentives to encourage their use. Because many projects suitable for VRF are smaller and don't require energy modeling, program implementers would prefer to offer prescriptive incentives for VRF systems. However, varying costs and installation circumstances have made it difficult for implementers to demonstrate cost-effectiveness consistently enough to develop a prescriptive approach.

In order to better understand the costs of VRF in common applications, an energy efficiency program implementer launched a 2015 pilot focused on new construction and major renovation projects. Under the pilot, the implementer offered customers prescriptive and custom incentives in exchange for providing detailed estimates of incremental cost. To build this offering, the implementer created energy models of prototype buildings to estimate savings for three main building types, researched VRF modeling protocol and created modeling and costing guidelines for participants.

The implementer expects at least five projects to have completed the pilot, providing detailed cost information and modeled savings results. In this presentation, we will share the savings and costs from these projects, discuss implications for prescriptive measure development, and present lessons learned, such as system and building suitability and design and performance issues uncovered.

Introduction

Energy Trust of Oregon is an independent nonprofit dedicated to providing energy efficiency and renewable energy services and incentives for electric and gas customers of four separate investor-owned utilities. Energy Trust's New Buildings program (New Buildings) provides incentives and technical support to new construction, major renovation, and tenant improvement projects, across all commercial building types. CLEAResult has served as the Program Management Contractor for New Buildings since 2009.

As a new construction program, New Buildings uses the prevailing energy code (the Oregon Energy Efficiency Specialty Code – OEESC) to define the baseline for most of its measures. This creates a persistent challenge for measure and offering design since the OEESC, along with other energy codes across the nation, continues to increase in stringency. In 2014, Oregon adopted new HVAC equipment efficiency standards in line with ASHRAE Standard 90.1-2013. For a state with a relatively mild climate and with low power costs, the result was a significant decrease in the ability of utility energy efficiency programs to provide prescriptive incentives for high efficiency heating, ventilating and air conditioning (HVAC) equipment. In order to continue to support projects looking for efficiency options, New Buildings identifies technologies that may have high market adoption potential and that are cost effective or likely to be cost effective as market adoption increases and costs are reduced. When one of these technologies is identified, but additional information is needed to better understand the technology and its place in the market, this technology is piloted to gain additional insights into both savings and incremental costs that will hopefully lead to a prescriptive program offering.

New Buildings supports energy efficiency in buildings through a number of program offerings. Owners of smaller, simpler projects typically apply for incentives for prescriptive measures. Larger, more complex buildings typically utilize the program's offerings where incentives are calculated based on energy saved as shown in an energy model. All energy efficiency measures must meet the program's cost effectiveness criteria in order to qualify for incentives. A measure's cost effectiveness is a function of its energy savings, incremental cost compared to the baseline technology, and the incentive which will be provided for the measure. To be considered cost effective, a measure must provide enough benefit in energy savings to outweigh the cost of purchasing the measure, as well as the cost of incentivizing the measure (i.e. benefit-to-cost ratio greater than one). Therefore, the prescriptive approach is best suited for measures for which the program has a firm understanding of the anticipated savings and costs, giving confidence that the measure will be cost effective when installed in the approved applications.

In the next 1-2 years, New Buildings expects significant market uptake of VRF in multifamily, hotels, senior living facilities, offices, retail, government and schools. Based on project information provided to the program, more than one-third of government and schools projects enrolled in the New Buildings program are expected to install VRF systems. The size and scope of many of these projects is such that they are unlikely to pursue energy modeling incentives and will instead enroll in prescriptive incentive offerings. However, the uncertainty of savings and costs associated with VRF systems has thus far prevented New Buildings from developing a prescriptive VRF measure. In order to address this challenge, New Buildings designed a pilot to gather information on VRF system savings and costs, with the hope that this would inform the design of a new prescriptive VRF offering.

VRF Systems

VRF systems distribute refrigerant to the different zones using refrigerant piping. This refrigerant is supplied to zone-level indoor fan coil units, where it is used to either heat or cool the zone air depending on the space's needs. The refrigerant is then sent to an outdoor unit, where heat is either released from the refrigerant into the atmosphere, or taken from the atmosphere and put into the refrigerant via the vapor compression cycle. One outdoor unit typically serves multiple indoor units. In a "heat pump" VRF system, heat is only transferred between the indoor and outdoor units. In a "heat recovery" VRF system, heat can also be transferred between different indoor units, with special controllers directing the flow of refrigerant to move heat from zones needing cooling into zones needing heating.

VRF systems are widely considered to be energy efficient systems, with benefits including, but not limited to:

- Compressor energy savings from using high-performance variable-speed compressors
- Fan energy savings from reducing or eliminating ductwork
- Ventilation energy savings from utilizing a separate Dedicated Outdoor Air System (DOAS), reducing overventilation and creating the potential for additional savings through the use of exhaust air heat recovery
- Integrated, sophisticated controls which may eliminate the need for a separate building automation system
- Reduced space requirements compared to other HVAC system types (such as smaller mechanical rooms, smaller mechanical chases, lower floor to floor height)
- Improved comfort

There are also indications that variable refrigerant flow systems are gaining U.S. market share. Reports by Transparency Market Research[1] and others indicate that VRF systems are growing in popularity, with the U.S. HVAC industry working to offer more VRF products (Freas 2015). This is also shown in the number of projects looking to install VRF systems in the Energy Trust service territory. Only three projects with VRF systems closed in 2012-2013, with an additional 11 projects in 2014-2015. At least seventeen additional projects enrolled in the program are in design and considering VRF systems. New Buildings is capturing detailed information on these early projects to isolate estimates and inform program design plans to launch a prescriptive pathway, as market interest continues to increase.

Challenges of Defining a Prescriptive Approach for VRF

Though VRF systems are being looked at as an energy efficient HVAC option for new and existing buildings, the potential variation in both energy savings and incremental costs affects the ability of utility programs to determine the cost effectiveness of the technology for different building types, sizes, and locations, presenting a significant challenge to defining a prescriptive approach for the technology.

Energy Savings

While there are case studies showing that VRF systems are energy efficient, the actual magnitude of the savings achieved by VRF systems is still unclear. Multiple approaches have been taken to quantify the energy saving benefit of VRF systems, but there is still uncertainty regarding the actual energy savings. This uncertainty makes it difficult for utility programs to offer incentives for these systems across building types, different climate zones and even different applicable building codes as well as across various system configurations.

In the Green Proving Ground report on VRF systems (Thornton and Wagner 2012), savings of 30% to 60% of HVAC energy compared to a range of other HVAC systems were reported for VRF systems used as an alternate to both existing and new systems across a broad range of building types and climates. Similar estimates have been reported by other analyses and

[1] http://www.transparencymarketresearch.com/pressrelease/commercial-air-conditioning-systems-market.htm. Accessed on 3/7/2016.

project case studies, with some data being reported as total building energy savings[2]. However, as noted by Thornton and Wagner (2012), there is currently a lack of independent energy modeling protocols for VRF systems, as well as few reported studies of measured energy savings that are isolated to the VRF systems themselves.

One proposed approach to determining reliable savings estimates for VRF systems has been to use building energy modeling software. In the last few years, various entities have worked to improve the capability of common existing energy modeling software programs to analyze the performance of VRF systems. EnergyPlus has included a VRF module since the release of version 7 of the software, and while eQUEST does not contain a VRF module, three of the major VRF equipment manufacturers have developed performance curves and guidance documents to be used when using eQUEST to model the energy consumption associated with their equipment. However, even if current energy modeling software has the capability to accurately generate VRF energy *consumption* estimates, utility incentive programs must be able to determine reliable estimates of VRF energy *savings* in order to create prescriptive incentive offerings. This requires identifying and modeling the applicable baseline systems.

Utility programs for new construction and major renovation typically have requirements which define the baseline HVAC systems against which to compare proposed HVAC systems. For states which have adopted the IECC and/or ASHRAE Standard 90.1, the baseline is most likely to be determined following the ASHRAE 90.1 Appendix G guidelines, which lay out a number of different baseline systems based on building type and size: packaged single zone systems, packaged rooftop variable air volume with direct expansion cooling, variable air volume with chilled water, and packaged terminal heat pumps. The specific design of these baseline systems is further defined based on the proposed heating source – electric heat versus fossil fuel – with some utility programs requiring that the heat source be consistent between the baseline and proposed systems in order to prevent fuel switching. For example, a multifamily building may propose to install VRF and a DOAS that has fossil fuel heating. The baseline for VRF would typically be a heat pump (packaged terminal heat pump for multifamily); however, the addition of the fossil fuel heating in the DOAS would suggest the need for fossil fuel heating in the baseline.

Once the baseline system has been chosen, the applicable energy code must also be taken into account as it dictates the baseline equipment efficiencies. These considerations result in significant baseline variability between different utility programs, as well as between different building types within the same utility program, creating additional challenges in the determination of VRF energy savings and hence the appropriate prescriptive incentive levels.

Incremental Costs

Incremental cost estimates for VRF systems are similarly difficult to define and are affected by many of the same factors which produce variability in savings estimates. New construction programs often base measure cost effectiveness on incremental costs as opposed to overall measure costs, the idea being that projects are investing more money to purchase an energy efficient option instead of a code-minimum baseline option. The incremental cost is defined as the difference between the cost of the efficient technology and the cost of the baseline

[2] http://www.seventhwave.org/new-technologies/variable-refrigerant-flow-vrf. Accessed 5/2/2016.

technology. As discussed above, there can be significant variability when attempting to define the baseline against which to compare a VRF system, making it difficult to determine a widely-applicable prescriptive incremental cost assumption.

An additional challenge in defining the incremental cost of VRF systems is determining which of the various building costs should be included in the estimate. This process is relatively straightforward when focusing solely on the major system components: the cost of the VRF indoor and outdoor units should be compared to the cost of the baseline HVAC units. However, there are a number of other HVAC-related costs that can be expected to vary between the baseline and proposed cases, including ductwork/piping design and installation, controls programming, system startup/testing, and ongoing maintenance. Additionally, VRF systems may have an impact on other building costs that are not specifically HVAC system costs, including mechanical equipment space requirements, structural design, electrical requirements and floor-to-floor heights. If any of these costs change as a direct result of choosing a VRF system over a baseline system, they should be included in the cost effectiveness calculation to paint an accurate picture of the costs and benefits of the system.

Developing a Utility Pilot Program for VRF

Preliminary Study

Prior to developing a pilot offering for VRF, the program conducted a literature review as well as a detailed review of projects with VRF systems that were enrolled in New Buildings. The purpose of this preliminary study was to identify the building types, if any, where VRF systems appeared to be most appropriate (from a technology application perspective as well as from a program cost effectiveness perspective). Savings and incremental costs from this review were analyzed considering the baseline system type, project type (new construction versus major renovation and building type), and climate zone. Numerous data sources were used to identify these savings and costs (EES Consulting 2011, Hart and Campbell 2011, LG 2012, Mistubishi 2014, Thornton and Wagner 2012). Understanding the range of savings and costs allowed the program to analyze the potential cost effectiveness of VRF systems as well as identify whether the savings, incremental costs or both savings and costs should be the focus of a future pilot offering.

Energy Savings

Savings were compared in three different ways: kWh savings on a per square foot basis, total percent reduction in HVAC energy end use, and total percent reduction in whole building energy end use. Energy consumption of prototype building energy models (based on the Department of Energy Commercial Prototype Building Models) used for other program offerings was used to estimate energy savings where percent reductions were reported. The models also reflected the current Oregon energy code (2014 OEESC). For purposes of our study, we did rule out data from projects that were known to be in climate zones significantly different from the Pacific Northwest. While this paper is not intended to provide a detailed summary of this research, the following summarizes the energy savings data:

- An average energy savings of 2.9 kWh/sf/yr was found after analyzing all data sources, including office, retail, school, and multifamily building types and multiple baseline system types including variable air volume (VAV), packaged single zone (PSZ) and packaged terminal heat pumps (PTHP)
- Energy savings were higher for an office building with a VAV baseline, ranging from 1.73 kWh/sf/yr to 4.82 kWh/sf/yr
- Savings for office, retail and schools that used a PSZ baseline ranged from 1.7 to 3.3 kWh/sf/yr
- Multifamily savings with a PTHP baseline ranged from 1.6 to 3.2 kWh/sf/yr
- Average whole building energy savings ranged from 14% (retail and office) to 31% (multifamily)
- HVAC energy savings ranged from 13% for office applications with a PSZ baseline to 63% for an office with VAV, with average savings across all building types of about 35%

Factors that could not be evaluated based on the data sources included baseline equipment efficiency, location and climate zone, and hours of operation. Several sources also indicated additional savings for projects installing heat recovery VRF systems and that a majority of new systems being installed are heat recovery. However, it was not always clear in the savings estimates if heat recovery or heat pump systems were being evaluated.

Incremental Costs

Incremental cost data were more difficult to find. The range of costs was also considerably larger than expected, ranging from $0.23/sf (EES Consulting 2011) to $11.97/sf[3]. The summary provided by the Washington State University Extension Energy Program[4] identified baseline costs ranging from $12 to $15 per square foot for a code-minimum system, compared with a VRF cost of about $18 per square foot. Where costs were identified relative to a given baseline, incremental costs for a packaged single zone system baseline were higher than for a packaged VAV baseline. Unfortunately, several sources of incremental cost data did not identify what aspects of the system equipment and installation costs were included.

Preliminary Cost Effectiveness Analysis

The next step in the process was to take the range of savings and incremental cost data and input the results into the Energy Trust's cost effectiveness calculator which calculates a benefit-to-cost ratio (BCR). The results of this analysis showed that, while there was no clear indication that VRF is a cost effective technology across building types and sizes for the range of savings and incremental costs, there were likely cases in which the technology would be cost effective. There was fairly consistent information on the relative energy savings associated with the technology, both as electric savings per square foot and as a percentage of HVAC savings. Though instances of cost effectiveness were evident, the range of incremental costs was enough to question the overall cost effectiveness required to create a prescriptive measure. Based on these findings, as well as the likelihood of installation and equipment costs decreasing as more

[3] New Buildings cost estimates from a cost consultant hired in 2011.
[4] http://e3tnw.org/ItemDetail.aspx?id=200#citation_2265

systems are installed, a final determination was made to develop a pilot offering that focused more specifically on the incremental costs associated with VRF systems.

The study also identified larger office buildings with a variable air volume system as baseline and multifamily buildings with a packaged terminal heat pump baseline as the most likely settings in which VRF would be cost effective. Perhaps not coincidentally, these are also the two building types in which the New Buildings program most commonly sees VRF systems installed. While smaller office and K-12 schools showed less certainty of being cost effective, they were also recommended for inclusion in the pilot based on market uptake.

Pilot Development

The VRF pilot was designed to allow both projects that were interested in prescriptive incentives, and projects interested in whole building analysis through the program's custom offering, to participate. The pilot is specifically focused on identifying applications for which VRF is a cost effective technology by capturing data on the range of incremental costs and the drivers affecting the cost effectiveness (such as baseline system type, building location, building type, etc.). Selected projects will have two paths for participation in the pilot: prescriptive and custom (also called modeled) savings. The program seeks to identify 15-20 projects that are likely to be cost effective based on the preliminary study and that have construction dates ending in 2016 and early 2017. Projects enrolled in the pilot will be qualified to receive installation incentives for the VRF systems, regardless of cost effectiveness, provided they compile and submit to the program detailed cost information.

The first step in the development was to create energy modeling guidelines to be used for estimating the energy savings by building type. This guideline document was developed for use with eQUEST, the predominant modeling software used in the New Buildings program. Each of the three most common manufacturers of VRF systems seen by the program – Daikin, LG and Mitsubishi – have developed performance curves and guidance around the eQUEST HVAC system types that should be used to model the performance of their systems. The published documentation was used to develop a guide for program use that includes detailed directions on how to model the systems in eQUEST for submission to the program.

This guidance was also used internally on the previously mentioned prototype models to estimate the savings for each of the three manufacturers, as compared to the relevant baseline systems that were already modeled. The savings estimates (see Table 1) were then averaged and used as the basis for both claiming prescriptive savings from the pilot as well as for setting the prescriptive incentive levels. From this analysis, a per-cooling ton incentive was developed, with the savings claimed for each project to be based on building type, Oregon climate zone (coastal, Willamette Valley, and central Oregon), and manufacturer. For projects that have significant variations from the prototype model assumptions (such as a lodging building being analyzed using the multifamily model), the program will modify the applicable model as needed and use the output to update the claimed energy savings. For projects that complete energy modeling in the custom offering, the incentive will be calculated as it is for all other projects enrolled in the offering, with the incentive tiered based on percent energy savings beyond code. Even if the pilot measure is found to not be cost effective, the program will pay the installation incentives.

Table 1. Assumed Energy Savings for Prescriptive Offering

Building Type	Weighted Average Savings (kWh/sf)	Weighted Average Savings (kWh/ton)	Proposed Incentive
School	2.2	888	$150/ton
Multifamily	2.4	1,047	
Office	3.5	999	

Savings are weighted by number of projects in three Oregon climate zones (ASHRAE climate zones 4C and 5B) and are the average values from the three modeling methods.

In addition to defining the modeling process, the program created a guidance document for how projects should document the incremental costs. The following categories of cost are included: equipment, system controls, dedicated outdoor air systems, ductwork, refrigerant lines, electrical, structural, additional floor area, floor-to-floor height, installation, and building/system commissioning. Each pilot participant will be required to document in as much detail as possible the costs associated with both the baseline and VRF systems.

Pilot Requirements

The pilot targets office, school and multifamily applications, although other building types will be considered for participation on a case-by-case basis. Savings may need to be adjusted for prescriptive projects that do not fit within the modeled building types. The goal is to obtain detailed information from a range of project types that will demonstrate with reasonable certainty that the technology is cost effective for each given building type and location. There are, however, specific technical requirements that each project must meet in order to be eligible. These requirements are put in place to ensure that the energy savings that have been estimated are likely to be achieved, as well as to address common concerns that are raised regarding the installation of VRF systems. Each of the requirements is described below.

Energy code compliance. The 2014 version of the Oregon Energy Efficiency Specialty code added new tables (503.2.3(10)) defining the minimum allowed heating and cooling efficiencies for VRF systems installed in Oregon. The New Buildings program is a market transformation program, and so this requirement serves to help raise the market's awareness of these new, system-specific requirements.

Separate ventilation system. The energy performance of HVAC systems may be improved when space cooling and heating loads are decoupled from ventilation load, as the air handler and ducts can be right-sized to handle the load. Using a dedicated outdoor air system (DOAS) in conjunction with a VRF system allows a building to use a separate central system to temper incoming ventilation air to a neutral temperature, instead of potentially straining the capacity of the VRF system by requiring it to bring outside air to room temperature. Using a DOAS also creates the potential for additional savings through exhaust air heat recovery. As such, pilot projects are required to utilize a separate ventilation system in order to achieve savings that are both higher and comparable to the modeled results. When required by code, exhaust air heat recovery must be included in the DOAS. Both heat pump and heat recovery VRF systems are acceptable.

Ductless indoor units. Ductless fan coils are specified to ensure that the significant fan energy savings assumed in the energy modeling are achieved. Heller (2015) noted that VRF ductless fan coils use between 8 and 15 watts for every 8,000 Btu/h in cooling capacity, as opposed to ducted units that use around 85 to 96 watts for every 8,000 Btu/h for medium static ducted and low profile ducted units, respectively. Therefore, VRF systems with ductless indoor units were identified as the most likely configuration to be cost effective.

Heating and cooling set points. Discrete heating and cooling set points with a 5°F dead band are required to ensure that the VRF system does not excessively cycle between heating and cooling operation. This control set up is required by the OEESC, and it is called out explicitly in the pilot as VRF systems may be particularly susceptible to cycling due to the constant availability of both heating and cooling.

Refrigeration safety. VRF system design involves running multiple refrigerant lines throughout a building's occupied space. As refrigerant is a toxic (and sometimes flammable) substance, special care must be taken to ensure occupant safety. Pilot projects are required to demonstrate that their installed VRF systems are in accordance with ASHRAE Standard 15-2011.

Commissioning and testing. VRF systems can be significantly more complex than their baseline counterparts, involving multiple interacting components and complex control sequences. Therefore, care should be taken to ensure that VRF systems are set up to operate correctly and achieve the full potential of their energy performance.

Pilot Evaluation

Energy Trust of Oregon has hired an independent consultant to evaluate the VRF pilot offering. There are two primary tasks of the evaluation. The first is to review the pilot materials to determine if appropriate baselines have been used and if estimated savings align with the design assumptions. The second task will be to review the cost effectiveness of individual projects participating in the pilot. Also as part of this task, the evaluator will research trends in costs and system configurations to aid in projects of future cost effectiveness. There is currently no plan to evaluate the actual project savings; however, these projects may be included in other program impact evaluations.

Early Results

During the creation of the pilot offering, the program identified 24 projects closing in 2015 through 2017 that were considering installing VRF systems. Unfortunately, as of early 2016, nine projects had submitted an application for participation in the pilot, and of these only six met the requirement for installing ductless fan coil units. As seen in Table 2, five of the projects are multifamily and lodging projects. Data from past projects that participated in the program's custom offering is also being considered, despite not having the same level of detail on the incremental costs and with potential variation in how the VRF systems were modeled.

Table 2. Projects Enrolled in Pilot To-Date

Project Building Type	Project Size (Sq ft)	Installation Date
Senior care/multifamily	50,000 – 100,000	2017
Multifamily	50,000 – 100,000	2016
Multifamily	>150,000	2016
Multifamily	50,000 – 100,000	2015
Lodging	50,000 – 100,000	2017
Office	< 50,000	2016

Cost effectiveness results from three pilot projects that have submitted cost information are summarized in Table 3, along with results from past projects enrolled in the program's custom offering for reference.

Table 3. Summary of Project Incremental Cost Data

Project Type	Project Size	Incremental Cost	Detailed Cost Data?	Cost Effective? (BCR)	Pilot or Other (Pre-Pilot)
Office/Mixed Use	50,000 – 100,000	$2.1/sq ft	No	Yes (1.5)	Other
University	100,000 – 150,000	$3.8/sq ft	No	Yes (1.6)	Other
University	50,000 – 100,000	$0.6/sq ft	No	Yes (3.2)	Other
Medical Office	<50,000	$2.0/sq ft	No	Yes (1.9)	Other
University	<50,000	$1.2/sq ft	No	Yes (2.6)	Other
Lodging	50,000 – 100,000	$4.0/sq ft	Yes	No (0.3)	Pilot
Multifamily	50,000 – 100,000	$6.0/sf	No	No (0.2)	Pilot
Small Office	<50,000	$3.2/sq ft	Yes	Yes (9.2)	Pilot

The savings for the lodging project listed in Table 3 were determined by modifying the multifamily VRF model with project-specific lighting power densities, occupant densities, equipment power densities, and outside air requirements. With the estimated savings and submitted costs, two VRF systems in the pilot were far from cost effective with a BCR of 0.3 and 0.1, while the program considers measures to be cost effective if the BCR is at least one. However, the costs submitted only took into account HVAC-specific items – there were no mentions of costs or cost-savings related to items such as maintenance, structural design, and floor space savings, which may be impacted by selecting a VRF system.

Early Lessons

The pilot was launched in late 2015. While the number of projects submitting applications is less than originally expected, there are a number of early lessons that have been learned. As a result, some modifications to the pilot may be made to ensure sufficient data is collected. The following sections highlight these initial findings.

Incremental Cost Difficulty

As expected, the most challenging aspect of pilot participation has been the requirement to submit detailed incremental cost estimates. To truly capture all of the claimed cost savings associated with VRF systems, often multiple parties must weigh in on the costs. For example, the mechanical contractor can provide information on the costs of the HVAC equipment, but he/she does not necessarily have insight into the value of increased floor-to-ceiling height, an often-claimed benefit of VRF systems. There is currently no additional design incentive offered to help offset the costs associated with gathering design-related cost data. This may need to be reconsidered, should there be continued difficulty in obtaining the data needed.

Cost Effectiveness

For the two projects for which cost data have been submitted, the incremental costs are at the high end of the range identified in the literature search, leading to questions on the cost effectiveness of VRF for residential applications. The program will work with the project team to determine if there are project-specific causes for the higher than expected incremental cost or if there are other cost saving areas that should be explored. Energy savings for this building type may also need to be confirmed through the evaluation process.

Ducted Systems

As mentioned above, multiple projects have been disqualified from the pilot because they are installing VRF systems with ducted indoor units. Though the savings achieved are expected to be lower, it seems likely that projects are selecting ducted VRF systems in order to obtain many of the same perceived benefits associated with non-ducted VRF systems, and that the market is tending toward VRF systems in general without a particular preference towards indoor unit type. Therefore, these projects represent additional sources of valuable information regarding VRF systems that is not currently being collected due to their exclusion from the pilot. The program is investigating the possibility of modifying the pilot technical assumptions and requirements in order to allow projects with ducted VRF systems to participate, increasing the amount of information gathered by the pilot.

Conclusions

VRF is regarded as an energy efficient technology option, and the market is increasingly selecting VRF as a strategy to help move towards net zero energy buildings. Utility programs aim to support the market by providing incentives for these decisions; however the variability in estimated savings and costs makes it difficult to design a simple prescriptive offering with which to support projects installing VRF.

By piloting this technology, New Buildings hopes to gain a greater understanding of this technology which will help inform the design of a prescriptive VRF offering. The pilot will be evaluated by a third party evaluator to determine soundness of pilot documents and estimated energy savings as well as to review individual project cost effectiveness results.

By answering these questions, the goal is to design a prescriptive VRF offering to focus utility program support on applications in which VRF consistently achieves cost effective savings, therefore promoting the proper installation of this technology in the applications for which it is best suited. The pilot will also help identify the areas of greatest uncertainty and variability, as well as the areas where costs may still be changing. Results may also highlight performance issues that should be addressed in design, construction and commissioning of systems.

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