DR16.06: VRF Market Characterization for ADR Program Readiness

VRF SYSTEM PARTICIPATION IN AUTOMATED DEMAND RESPONSE

Demand response remains second in the energy resource loading order after energy efficiency (State of California, 2008). Some heating, ventilation, and air conditioning (HVAC) controls manufacturers are developing automated demand response (ADR)-capable controls. Variable refrigerant flow (VRF) manufacturers, on the other hand, already sell equipment with integrated controls capable of reducing demand.

Variable refrigerant flow (VRF) systems are an efficient alternative to traditional HVAC systems, which allow the user to vary the amount of refrigerant flow to individual zone compressors. VRFs are heat pumps that use inverter-controlled, variable speed compressors to modulate capacity to meet varying demand. These modular systems can be scaled from six tons up to hundreds of tons and consist of an outdoor condenser unit connected by refrigerant lines to multiple indoor evaporator units that serve each zone. This means that VRF systems are well suited for automated demand response (ADR) because of their higher efficiency, inherently flexible design, and zone-based controls.

However, the status of the ADR functionality of the VRFs currently available on the market is still emerging. This project enables SCE program staff to make informed decisions about the current ADR capabilities of VRF control systems and determine which are ready for accelerated commercialization in SCE incentive programs. Specific objectives included:

- Research the status of ADR-capable VRF controls among different VRF manufacturers;
- Review whether or not VRF controls meet demand response requirements in 2013 Title 24 energy code;
- Report on available plans by VRF manufacturers to offer ADR-capable controls.

INTRODUCTION

What Is This Technology?

VARIABLE REFRIGERANT FLOW (VRF) SYSTEMS

A variable refrigerant flow (VRF) system is an efficient HVAC alternative to conventional unitary air conditioner and variable air volume (VAV) systems. VRF systems consist of heat pumps that use inverter-controlled, variable speed compressors to modulate capacity to meet varying demand. The system is comprised of an outdoor condenser unit which is connected by refrigerant lines to multiple indoor evaporator units, with each indoor evaporator unit serving an individual zone. The outdoor unit contains the compressor, condenser, propeller fan(s), circuit board and a heat exchanger coil, while the indoor unit consists of a heat exchange coil, expansion valve, air filter, and fan. The units can be either air or water sourced, and function by varying the amount of refrigerant sent to each indoor evaporator unit based on that zone's specific needs.

VRFs are integrated solutions with microprocessor controls that are networked together using proprietary digital communication protocols to coordinate their operations. Programmable functionality can exist at zonal, central, or system level.

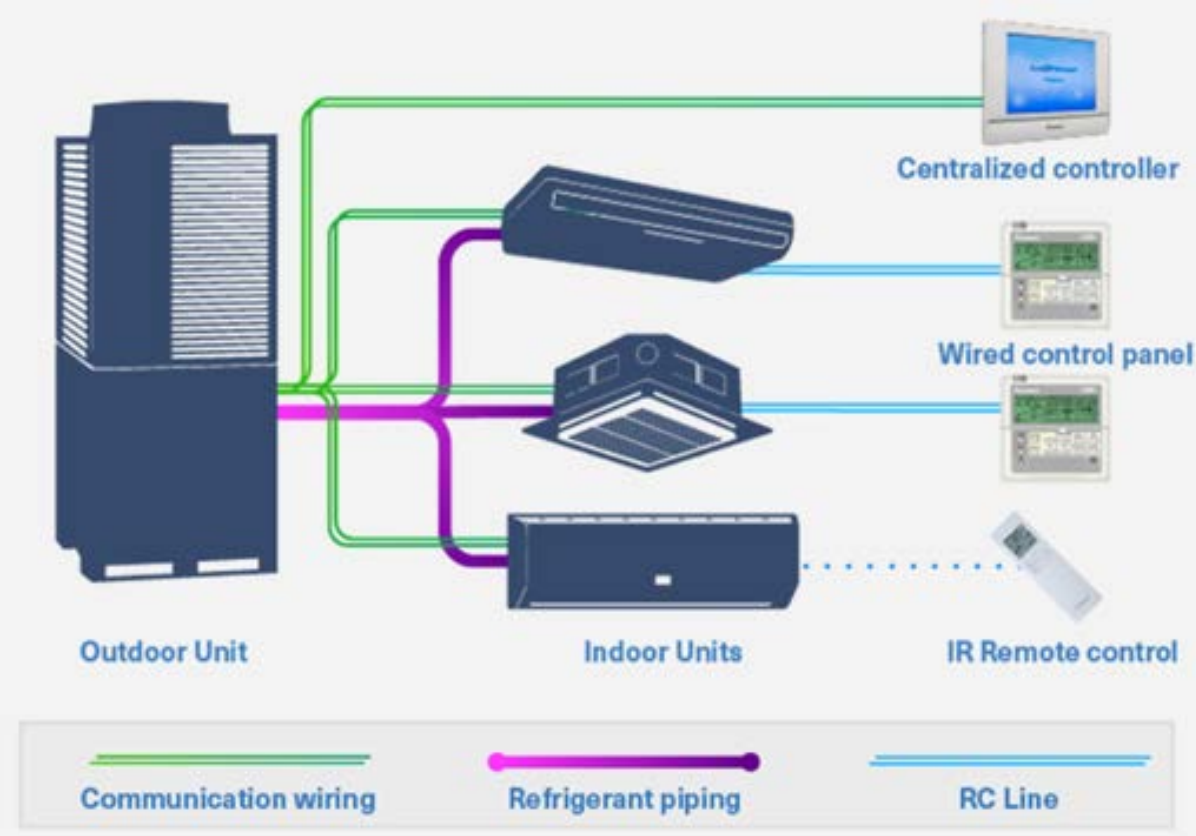
What We Did?

TECHNOLOGY AND MARKET RESEARCH

This project was a technology and market assessment characterizing the available DR strategies and ADR capabilities of VRFs. This included phone interviews with seven VRF manufacturers, discussing the key product features and HVAC controls parameters that can be used for demand response participation and what types of DR strategies can be implemented by the VRF controls. The interviews were supplemented by a web-based research of manufacturer websites, product literature, and relevant conference presentations.

The interviews with VRF manufacturers also included questions relating to the 2013 Title 24 code, to determine whether VRFs are required to meet the Automated Demand Shed Control (ADSC) measure or the Occupant Controlled Smart Thermostat (OCST) measure within Title 24. The Team also compared VRF capabilities against zone thermostat requirements in Title 24. Finally, the Team reviewed language in the ASHRAE 189.1-2014 code for high-performance buildings, discussing implications for VRF compliance.

Figure 1: Typical VRF System Structure (Source: CoolAir Australia)



FINDINGS

EXISTING DEMAND RESPONSE CAPABILITIES Each of the seven manufacturers interviewed had additional cost options which could be purchased to provide load shedding capability to the VRF system. These options include remote setpoint control, automated setpoint setback, turning off units in rotation, limiting the compressor demand, zone differentiation, power meter reading, and snapback control. It is worth noting that none of these options were available from all seven manufacturers interviewed. These potential load shedding options are not currently included in the base VRF system, nor do they have the capability to be automated.

OPTIONS FOR ADR EXECUTION While the capability for demand response exists within the VRF market, there is no current option which would allow for the demand response to be automated within the VRF systems. In California, in order to be eligible for utility technology incentives via the ADR program, the VRF systems would have to be able to be operated using the OpenADR 2.0 framework with the communication technology certified by the OpenADR alliance. There are three main options available to VRF manufacturers to add this capability to their systems. The preferred option, which is not yet commercially available, is using a central controller with a built-in OpenADR-certified Virtual End Node (VEN). The other options, which are currently commercially available, are to employ a second OpenADR certified VEN or if the VRF system is connected to the building Energy Management Control System (EMCS), to send the ADR signal to the EMCS.

CODE COMPLIANCE A major goal of this research study was to determine if the VRF technology was compliant with the demand response requirements in California's Title 24 Building Energy Code and in ASHRAE 189.1-2014. There are two types of possible measures in Title 24, the Automated Demand Shed Control (ADSC) measure and the Occupant Controlled Smart Thermostats (OCST) measure. The team determined that VRFs are required to comply with the ADSC measure, but do not fall under the OCST measure. However, no VRF manufacturer currently meets all the ADSC and zonal thermostat requirements of Title 24. ASHRAE 189.1-2014 guidelines suggest a demand response load shedding of 10% or more of the projected peak demand. Each of the seven VRF manufacturers interviewed have add-on options which would allow the VRF system to contribute to that load shedding.

MARKET CHARACTERIZATION In 2016, California sales of commercial VRF systems totaled 3,500 units, with an estimated market value of approximately $210 million. A "gap analysis" was performed between what is desired by the programs and what is offered by the market. At this time, the VRF manufacturers in California do not meet the Title 24 ADR requirements, and they have a wait-and-see attitude on making their VRF solutions fully ADR capable. The manufacturers are waiting for clear market signals from their customers and from utilities before adding ADR features to their systems.

Table 1: Summary of ADR Readiness, Number of Manufacturers

	VIA CENTRAL CONTROLLER	WITH OWN EMCS	CUSTOM VIA CONTACT CLOSURE	MANUAL ONLY
Receive OpenADR 2.0 Signals	n/a	1	n/a	n/a
Set and Reset Zone Temperature	2	1	3	1
Adjust Rate of Temperature Change by Zone	2	n/a	n/a	n/a
Demand Limit	3	n/a	3	1
Group Zones	2	3	1	1
Built-in DR Commands	0	0	0	0
Allow DR Commands Over System Network	3	n/a	n/a	n/a

CONCLUSIONS

What We Concluded?

MARKET SIGNALS NEEDED

At first glance, VRFs appear to be ideal solutions for ADR participation. Beyond traditional temperature setback strategies, VRF systems lend themselves to zone grouping, as well as the potential ability to differentiate DR strategies between critical and non-critical zones. As such, VRFs are an eligible measure in SCE's existing ADR Program, although no VRF project applications have been submitted to-date. However, VRF technology remains an untapped potential for ADR at this time. Despite having sophisticated controls and a built-in communications network between system components, the current ability of VRF systems to implement ADR is incomplete. While nearly all manufacturers offer demand response capabilities, these functions generally cannot be automated as they cannot be executed via commands from the VRF central controller. Furthermore, no manufacturer can currently receive OpenADR communications at the central controller without being relayed through a third-party VEN, or in some cases, the manufacturer's own EMCS product. If a customer wanted to participate in DR events, the VRF system will need to be custom-modified with additional programming required. This adds complexity and additional cost to implementing a DR solution.

These Findings are based on the report "Centralized Guest Room Controls," which is available from the ETCC program website, https://www.etcc-ca.com/reports.

Recommendations

The VRF manufacturers interviewed for this study were aware of demand response and acknowledge the opportunity for future implementation. This report has the following recommendations to encourage manufacturers to implement ADR:

CONFIRM ADR-READINESS: VERIFY DR/ADR FEATURES IN LAB SETTING

The control operations detailed by the manufacturers should be verified as laboratory demonstrations. This entails observing the operation of VRF controls in executing pre-programmed demand reduction sequences and documenting their actual sequence of operations. As well, end-to-end signal testing on the VRF systems using OpenADR 2.0 communications protocol should be conducted.

ENCOURAGE MANUFACTURERS: UTILITY ENGAGEMENT AND OUTREACH

SCE can send stronger and clearer signals to encourage the market by engaging with VRF manufacturers more frequently and more regularly. Additional education is needed on the requirements for voluntary DR programs and ADR participation, including OpenADR certification and the SCE DRAS configuration. Even for established manufacturers, the interviews revealed there were many questions relating to existing code requirements, DR Programs and ADR incentives Eligibility.

SIGNAL MARKET DEMAND: INCENTIVES

SCE can incent VRF manufacturers, distributors, and customers. Manufacturers can be incentivized to enhance and further integrate existing control capabilities to be more DR-friendly, such as demand limiting, cycling or rotating indoor units, improved displays, and reporting of DR events. Distributor incentives benefit VRF manufacturers by making equipment more affordable for a larger population of customers. Customer-focused incentive programs allow SCE to interact directly with customers to motivate DR program enrollment and active participation in DR events.