DR12.16 Testing of Commercial Variable Capacity Heat Pump (VCHP) for Small Commercial Office Buildings

OVERVIEW

Testing of Commercial Variable Capacity Heat Pump (VCHP) for Small Commercial Office Buildings

New technologies like Variable Refrigerant Flow (VRF) which employ inverter driven technology, variable speed drives for motors and compressors and inexpensive controls have made it possible to provide highly efficient and flexible cooling and heating.

Currently, energy savings derived from VRF use are generally considered difficult to characterize via any deem-able method and are thus typically modeled via EnergyPro, Energy Plus, and related building simulation software packages.

There is a need for detailed measurement of field performance of variable refrigerant flow heat recovery systems (VRF-HR) to both help characterize actual yearly energy savings potential, and to provide quality data for use in energy modeling verification.

This project will comprise instrumenting and measuring the in-situ performance of a VRF-HR system with the following objectives:

- To collect operational performance data on an installed VRF-HR system
- To collect a data set that is appropriate to provide energy modeling developers with a validation tool
- Provide objective analysis and performance characterization of a field installed VRF-HR system
- Assess the ability of an installed system to be a resource for load management/demand response (DR)

SELECTED SITE & VRF SYSTEM DETAILS

The selected site for this VRF field monitoring project is a 2-story office building with approximately 5,710 square feet of conditioned space. The VRF system installed at this location is a VRF system with heat recovery capabilities comprised of two main outdoor units and 17 smaller indoor units listed in the tables below.

Table 1: Outdoor Units

OUTDOOR UNIT (ODU)	MODEL NUMBER	COOLING CAPACITY (BTU/H)	HEATING CAPACITY (BTU/H)	FLOOR SERVED
ODU 1	Mitsubishi PURY-P144TKMU-A	144,000	160,000	1st (IDU 1-9)
ODU 2	Mitsubishi PURY-P144TKMU-A	144,000	160,000	2nd (IDU 10-17)

Table 2: Indoor Units

OUTDOOR UNIT (ODU)	MODEL NUMBER	COOLING CAPACITY (BTU/H)	HEATING CAPACITY (BTU/H)	FLOOR SERVED
IDU 1	PEFY-P36NMAU-E2	DUCTED	36	40
IDU 2	PEFY-P24NMAU-E2	DUCTED	24	27
IDU 3	PEFY-P18NMAU-E2	DUCTED	18	20
IDU 4	PLFY-12NCMU-ER4	CEILING	12	13.5
IDU 5	PKFY-P30NKMU-E2	WALL	30	34
IDU 6	PEFY-P15NMAU-E2	DUCTED	15	20
IDU 7	PEFY-P24NMAU-E2	DUCTED	24	30
IDU 8	PEFY-P12NMAU-E2	DUCTED	12	13.5

IDU 9	PEFY-P15NMAU-E2	DUCTED	15	17
IDU 10	PLFY-24NBMU-ER4	CEILING	24	27
IDU 11	PEFY-P36NMAU-E2	DUCTED	36	40
IDU 12	PEFY-P18NMAU-E2	DUCTED	18	20
IDU 13	PEFY-P12NBMU-ER2	DUCTED	12	13.5
IDU 14	PKFY-P18NHMU-E2	WALL	18	20
IDU 15	PEFY-P08NMAU-E2	DUCTED	8	9
IDU 16	PEFY-P36NMAU-E2	DUCTED	36	40
IDU 17	PEFY-P15NMAU-E2	CEILING	15	17

PERFORMANCE DATA

Data representing thermal and electrical characteristics of the VRF system was collected from the site for a period of 12 months –from April 2014 to March 2015.

The load shape of the VRF system is shown in Figure 1. The load shape in this document is defined as the average power draw (kW) during the hour for the entire system. This kW number includes outdoor unit power, power draw from all the indoor units, branch selector boxes and the fresh air fan. The load shape is further split out in terms of a summer shape and the average 12 months shape. Summer is defined time between as June 1st and October 1st. Summer load shape showed high demand during peak periods for utilities. The overall load shape for the 12 months also shows significant load during 'on-peak' hours defined as hours between noon and 6 pm.

Other performance data was collected such as total VRF system energy use for entire year, which was 43,418 kWh or 7.6 kWh/sq.foot/year.

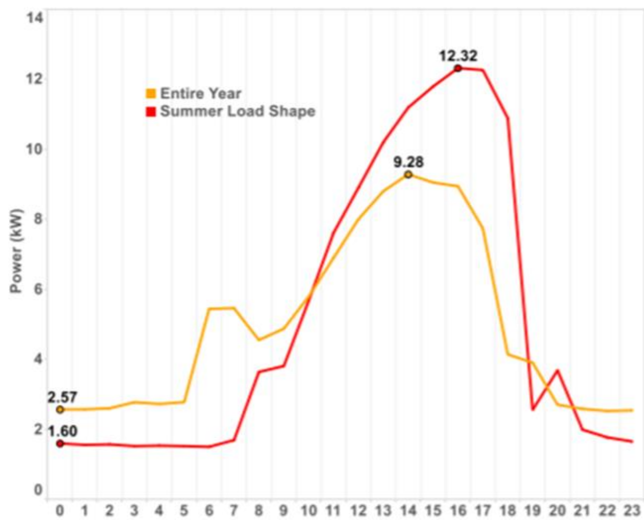

Figure 1: Load Shape of VRF System

(Average for Entire Years and Summer Months)

DEMAND RESPONSE

DR capabilities of the VRF system were demonstrated using OpenADR 2.0a messages sent from a Virtual Top Node (VTN) setup at EPRI. An additional controller setup on-site acted as an OpenADR Virtual End Node (VEN) and translated the OpenADR commands to native machine language for the VRF system. The control strategy was to increase the temperature set point by 3°F to reduce HVAC electric demand.

The system during a DR event shed a maximum of 1.7kW of load. The preliminary results are encouraging but the test was mostly for communications verification and was not carried out when the ambient conditions were high, and so the actual load impact was not representative of a summer peak day.

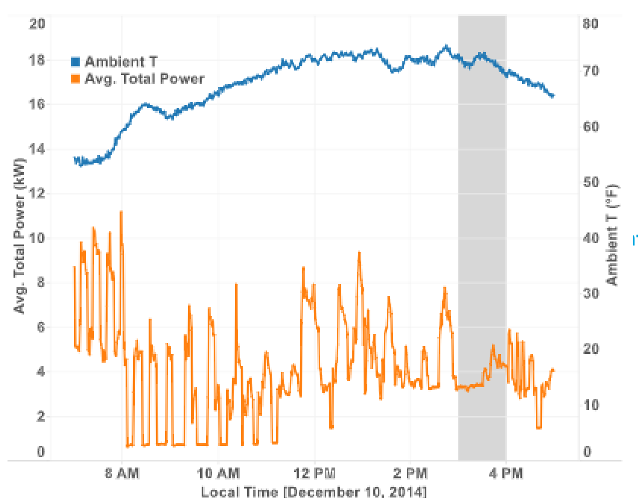

Figure 2: Power Draw and Ambient Conditions During DR Event

CONCLUSIONS

The monitoring and analysis of the VRF-HR system shows that the operating characteristics were in line with the expectations based on the understanding of HVAC systems. Findings and discussion summary:

1. Critical detailed measurement of field performance of variable refrigerant flow heat recovery systems (VRF-HR) to help characterize actual yearly energy savings was captured. The goal to provide quality data for use in energy modeling verification was realized.
2. It was imperative to assess the ability of the VRF equipment to communicate with an outside entity to receive the DR commands. An off-the-shelf controller was used to interface between the VRF systems controller and the public internet using wired connections. Some additional programming was needed.
3. Demand reduction via the OpenADR messaging was demonstrated by the system responding to a pre-scheduled DR event.

FUTURE WORK

To further expand on the OpenADR capabilities of the system and to include more testing, the EPRI project team intends to run numerous DR events during the summer season with a focus on a more detailed investigation of DR performance. When those tests are available, they may be incorporated into a future report.

The full findings are based on the report "DR12.16: *Testing of Commercial Variable Capacity Heat Pump (VCHP) for Small Commercial Office Buildings*", which is available at **www.dret-ca.com**.