BPA Emerging Technologies for Energy Efficiency
Technology Focus Area:
Variable-capacity Heat Pumps

Technology Background

Space heating drives winter peak electricity demand in the Pacific Northwest. Bonneville Power Administration has been researching variable capacity heat pumps for space conditioning as a potential technology to save energy and reduce winter peak demand. Instead of running at constant speed and cycling on and off, variable capacity heat pumps meet heating and cooling loads by using variable-speed compressors and fans. Additionally, instead of providing heating and cooling by blowing hot and cold air, these systems use refrigerant, which is much more efficient. Variable capacity heat pumps have several non-energy benefits as well; not requiring ductwork to meet the heating and cooling loads, better zone control, and quieter operation. Good applications for variable capacity heat pump retrofits include replacing electric resistance heating, replacing traditional heat pumps for improved zone control and quieter operation, and outfitting historical buildings, where there isn't room to add new ducting.

Current Research Projects

Field Test of a Variable Capacity Heat Pump in Residential Ducted Applications
Timeline: 2013 – 2014
Collaborators: Ecotope

This field study was designed to evaluate the performance and cost-effectiveness of variable capacity heat pumps as an energy-saving retrofit inducted residential applications. Data from eight sites is being analyzed to support inclusion of these applications in regional conservation programs.

Field Test of Ductless Heat Pumps in Residential and Commercial Applications
Timeline: 2010 – 2014
Collaborators: Ecotope

Mini-split ductless heat pumps were installed and metered in 51 locations, including single-family homes, multi-family homes, manufactured homes, and small, commercial buildings. One year of sub-metered data and electricity bills were analyzed for each site. Results were positive for manufactured homes and single-family homes, as a supplement to forced-air-electric furnaces. Measures will be presented to the Regional Technical Forum in late 2014 for provisional approval.

Completed Project Reports

Field Test of Residential Variable Capacity Heat Pumps
Timeline: 2012 – 2014
Collaborators: Tennessee Valley Authority (TVA), Electric Power Research Institute (EPRI), Oak Ridge National Laboratory (ORNL)

This project provided new insight and data on the operation of variable capacity heat pumps in ducted, residential applications for energy conservation and demand response. BPA teamed up with EPRI, ORNL, TVA, and other utilities to evaluate the energy-savings potential of variable capacity heat pumps at TVA's Campbell Creek Energy Efficient Homes in Knoxville, Tenn. The research homes are equipped with devices that mimic typical residential loads.

Lab Testing of a Residential Ducted Variable Capacity Heat Pump
Timeline: 2012 – 2013
Collaborators: EPRI

Working with EPRI, a performance map for a ducted variable capacity heat pump system was developed for a variety of climate conditions, including low ambient temperatures. The system performance maps were used to enhance energy simulation models and to compare variable-capacity heat pump performance to traditional efficiency metrics (COP, EER and IEER).

Field Test of Geothermal and Air-source Heat Pumps for Space and Water Heating
Timeline: 2010 – 2014
Collaborators: Ecotope

The "Place of Hidden Waters"project of the Puyallup Tribal Housing Authority consists of 20 low-income housing units in two nearly identical buildings. One building used a ground-source heat pump (GSHP) system to provide space and domestic water heating for the apartments. The other building used a central variable refrigerant flow (VRF) system to provide the same services. This study evaluated energy use of the two systems, through bill analysis and on-site audits.

The Place of Hidden Waters buildings used approximately 25 percent less energy for water heating and space conditioning than a typical multi-family building. However, the project team anticipated approximately double this level of savings. The shortfall appears to be primarily due to overly conservative heat pump controls with very low temperature set points for hot water. This report also includes lessons learned and best practices for designers of VRF and GSHP systems as well as recommendations for measuring GSHP and VRF energy use.

Lab Testing of VRF Heat Recovery Systems for Ducted, Commercial Applications
Timeline: 2010 – 2012
Collaborators: EPRI, Southern California Edison

This project developed detailed performance maps of three 6-ton variable-refrigerant flow systems with heat recovery (VRF-HR) in ducted applications. This project tested the four-zone VRF-HR systems over a range of conditions, with a focus on heating performance at lower ambient temperature conditions.

Results were compared to manufacturers' data and incorporated into building energy simulation modeling tools. With these energy simulation modeling tools, the energy performance of VRF-HR systems can be compared with other heating and cooling systems.

For more information on this technology, reports, and collaboration opportunities, please visit our website.
www.bpa.gov/goto/E3T