Technology Innovation Project

Closing Project Brief

TIP 292: Advanced Heat Pump Water Heater Research

Context

The 6th Power Plan calls for a 50% penetration of heat pump water heaters in the Pacific Northwest Region (PNWR) by 2030. According to the recently released Residential Building Stock Assessment, 55% of the region's residences have electric water heaters, of which only 0.02% are heat pumps. Concerns expressed about this technology include: the sufficiency of hot water supply; the demand response potential; and performance of the technology in colder climates. Some utilities have expressed concerns about homeowner comfort when installations are inside the conditioned space and are reluctant to support the current market integrated systems. They are especially interested in split systems which do not remove heat from conditioned space; however they want to see how the technology works in regional climate zones.

Description

Washington State University Energy Program (WSUEP), in partnership with Avista, Energy Trust of Oregon, Northwest Energy Efficiency Alliance (NEEA), Ravalli Electric Co-op and Tacoma Public Utilities, conducted research and demonstrated the capabilities of high-performance, next-generation heat pump water heaters in the laboratory and in the field.

The project brings a split system, carbon dioxide (CO_2) heat pump water heater with a dedicated, variable-speed outdoor compressor, to the Pacific Northwest, where it was subjected to the same lab and field tests as the integrated heat pump water heaters already marketed in the region. The research took place over three years. In the first year the equipment was imported and lab tested. In the second and third years it was field tested at four sites located in all three of the region's heating zones.

The equipment solves the issue of increasing the space-heating load of residences served by integrated heat pump water heaters. This CO_2 refrigerant technology represents a significant increase in heat pump water heater performance over existing technology.

The specific tasks involved in this project include:

1. Select and import four split system CO_2 heat pump water heaters.
2. Conduct lab tests to national and regional protocols.
3. Analyze lab data and report
4. Select field sites, obtain permits or waivers, execute homeowner agreements, and install HPWHs and monitoring equipment
6. Conduct field tests to regional protocols
7. Analyze field data and report

Benefits

BPA is undertaking a multi-year effort to identify, assess and develop emerging technologies with significant potential for contributing to the goals of efficiency, capacity reduction, demand-response and climate change remediation.

Currently, the PNWR is heavily invested in integrated heat pump water heater technology with single speed compressors, limited to a rated Coefficient of Performance (COP) of 2 to 2.5. WSUEP proposes to introduce a variable speed split system with a COP rated greater than 3 in normal conditions, and a COP of 2 in temperatures as low as 17° F.

Assuming an average annual hot water load of 3,300 kWh and an average annual COP of 3, the annual savings would be approximately 2,200 kWh per residence. This system does not add to the space heat load of the home to which it supplies hot water. It may prove to be a crucial technology for heat pump water heaters.

Accomplishments

The CO2 refrigerant, split-system heat pump water heater was tested in both lab tests and at four field sites representing the three heating zones in the Pacific Northwest. This is a promising technology. The field tests demonstrated the assertions of the lab tests, and that this technology has great promise as an efficient water heater in all climates of the Pacific Northwest.

The efficiency plus a modest value for significant permanent capacity reduction make these CO2 HPWH cost effective compared to an electric resistance water heater (ERWH). When values for DR and climate benefit are included, the cost effectiveness increases.

Additional technology transfer will include presentations at major regional and technical conferences; introduction of energy efficiency measures to the Regional Technical Forum; advocacy to regional utilities; and coordination with national groups such as CEE and EPRI.

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Project Start Date: December 7, 2012

Project End Date: December 31, 2015

Project Cost

Total Project Cost: $720,000

Deliverables

Advanced Heat Pump Water Heater Research: Final Report, Ken Eklund, Washington State University Energy Program, Ben Larson, Ecotope

For More Information Contact:

Technology Innovation Project Management Officer:
TechnologyInnovation@bpa.gov

Results

The lab and field test data on the Sanden GAU split system HPWH show these systems can provide the hot water needs of a family of up to seven without backup heat during a cold winter (with low temperatures ranging from almost -16°F in Montana, 2°F in Spokane, and the 20s°F in Portland and Tacoma).

The energy needed to heat water in the field study averaged approximately 0.05 kWh per gallon used. This is half the energy needed by standard unitary HPWHs according to recent analysis of a long-term field study done by Ecotope. At least some of these standard units took energy from interior space, so the actual performance benefits of the split-system are greater.

Conclusions:

The next step for this technology is commercialization. This project has helped and encouraged the manufacturer to pursue UL listing for the system studied in this research. The split system meets all U.S. plumbing and electrical standards with advanced freeze protection and UL listing. It will soon be available for purchase at the price stated in the cost-effectiveness section.

Related Projects

TIP 302- Demand Response Potential of CO_2 Heat Pump Water Heaters

Participating Organizations

Washington State University Energy Program
Ecotope, Inc.
Avista Corporation
The Energy Trust of Oregon
Northwest Energy Efficiency Alliance
Ravalli Electric Co-op
Tacoma Public Utilities