COLD CLIMATE HOUSING RESEARCH CENTER
CCHRC

Final Report

Air Source Heat Pumps for Residential Baseboard Heating

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Abstract

CCHRC conducted market research to identify air source heat pumps (ASHPs) designed for typical residential baseboard applications. There are currently no such ASHPs commercially available in the United States. Daikin North America and Mayekawa are currently developing high temperature ASHPs that could work for baseboard systems, but timelines for commercialization are uncertain. For homeowners interested in retrofitting their heating system with an ASHP, CCHRC does not recommend waiting for a high temperature ASHP model to become available, but instead considering options already on the market that use a different method of heat delivery.

Keywords: heat pump, baseboard, hydronic

Air Source Heat Pumps for Residential Baseboard Heating

Air-to-water heat pump systems for residential applications are designed for low-temperature hydronic heating, such as in-floor radiant heating. These air source heat pumps (ASHPs) supply hot water at approximately 90 to 110°F, with maximum supply water temperatures around 130°F. In contrast, conventional baseboard hydronic heating uses finned-tube baseboard convectors that are designed for substantially higher supply water temperatures. The thermal ratings of finned-tube baseboards typically range between 150 and 220°F (Siegenthaler, 2004). Hereafter these will be referred to as "high-temperature baseboard".

High-temperature baseboard heating is common in many residential buildings in Alaska, creating a disconnect between typical hydronic heat distribution and ASHPs available for home heating. Kodiak Electric Association (KEA) and Alaska Electric Light & Power (AEL&P) contracted with CCHRC to identify ASHP options for homes with baseboard heating. CCHRC conducted market research to identify if there are ASHPs currently on the U.S. market designed for residential baseboard applications.

Methodology

From August through October 2014, CCHRC staff interviewed several experts in the HVAC industry and reviewed literature relating to hydronic ASHP applications. The literature review included product literature from heat pump distributers, articles from construction journals, and manufacturer websites. Interviewees included air source heat pump installers, HVAC equipment retailers, and researchers.

High and low-temperature hydronic applications can be distinguished by ranges of supply water temperatures and other design factors, not absolute boundaries. However, 150°F was used as an evaluation criterion to simplify the distinction between a high and low-temperature systems. Therefore, an ASHP needed to supply water at a temperature greater than 150°F to be considered compatible with high-temperature baseboard.

Findings

CCHRC did not identify a commercially available ASHP in the United States that is capable of supplying a high-temperature baseboard distribution system. There are ASHP systems operating in Alaska using low-temperature hydronic heating, and some higher-temperature ASHP systems in development, but the current market does not include an option pairing an ASHP with high-temperature baseboard.

No residential ASHPs compatible with high-temperature baseboard are available.

Currently no Alaska heat pump installer or HVAC distributer has an ASHP model compatible with high-temperature baseboard in residential buildings. Based on CCHRC's findings, it appears that no such ASHP is currently available in the United States. Several distributers and manufacturers provided recommendations for alternative ASHP options for hydronic heating for homes.

A representative from Gensco, which distributes Mitsubishi heat pumps, did not recommend installing one of their models with high-temperature baseboard. Gensco currently distributes a heat pump (Y-Series models) which uses a booster to temporarily reach water temperatures up to 160°F, but was unable to estimate how this might integrate with high-temperature baseboard distribution (C. Roark, personal communication, October 1, 2014).

Daikin North America recommends installing one of its current Altherma models in conjunction with low-temperature baseboard emitters. There is currently one installer for Daikin in Juneau that installs the Altherma air-to-water heat pumps with low temperature baseboard distribution. Three residential applications have been completed in Juneau, all of which employ the Altherma paired with Smith Heating Edge two-pipe baseboard heat emitters (R. Simpson, personal communication, September 29, 2014).

Representatives from Stinebaugh and Company and Ferguson Enterprises also expressed a preference for using low-temperature hydronic heating (T. Bolty and D. Franklin, personal communication, August 5, 2014).

The Japanese company Mayekawa has a high-temperature ASHP model (EcoCute) that uses carbon dioxide as the refrigerant. A University of Strathclyde study evaluated the European EcoCute model using a literature review, modeling, and monitoring of installations in Finland and concluded that the EcoCute's efficiency depended on the water temperature returning to the ASHP from the hydronic distribution system. Although the EcoCute is capable of delivering high enough water temperatures for high-temperature baseboard, they recommended using low-temperature distribution system for better performance (Petinot et al., 2010). These findings were confirmed by Troy Davis of Mayekawa USA. Mayekawa has an ASHP available in the United States, but it faces challenges to integrate with high-temperature baseboard in residences (T. Davis, personal communication, October 2014):

1. The heat output is too high for most residential building heating loads (256 to 375 kBTU/hr heating capacity).
2. The best performance is realized when there is a 50°F temperature difference across the inlet and outlet water temperature. This is significantly higher than found with typical baseboard distribution. Mr. Davis suggested that this heat pump might be able to work for applications that would have a lower the return fluid temperature, such as a snow melting.
3. Specific to Alaska, this heat pump currently has an operational limit of 12°F ambient air temperature. Mayekawa is working on a model that will work at lower ambient temperatures, but it is not currently available.

Available information on ASHP technology in development is sparse.

Companies are developing products that could integrate ASHP technology with baseboard distribution; however, information on the development timelines is unclear.

One example of ASHP technology development is the Sanden GAU heat pump water heater currently available in Australia. Unlike the residential heat pump water heaters currently available in the United States, the Sanden does not have any electric resistance heating elements and has an outdoor evaporator unit. An evaluation conducted within the United States characterized the performance of the system from simulated climate conditions ranging from 17 to 95°F (Larson, 2013). The Sanden uses carbon dioxide as a refrigerant, and therefore represents technology development that could potentially result in high-temperature ASHP systems. Representatives from Sanden attended the International Air-Conditioning, Heating, Refrigerating Expo® at New York City in early 2014 to show new products planned for U.S. distribution. A video from the Expo showed a new system that combined hydronic space heating and domestic hot water capabilities. The video made a reference to low-temperature hydronic heating, though technical specifications were not available.

Residential high-temperature ASHP systems are in development for North America by Mayekawa and

Daikin North America, but nothing was available for a demonstration project. Details on the status of this technology development and anticipated timeframe for commercialization were not available. Mr. Davis of Mayekawa cited the lengthy UL product safety certification process for residential heat pumps as one reason for the uncertainty in product launch timelines (T. Davis, personal communication, October 2014).

The International Energy Agency Heat Pump Centre provides information about heat pump trends and technology development. Annex 41 is a working group within the center focused on the development of a cold climate air source heat pump for ducted air distribution. The U.S. representative for Annex 41 was not aware of an air-to-water heat pump that could supply the necessary water temperatures for high-temperature baseboard applications (V. Baxter, personal communication, October 14, 2014).

The Northwest Regional Sales Manager for Panasonic, Ken Nelson, stated that the company is currently developing a ductless ASHP product for North America. Ken did not know of any work within Panasonic for high-temperature hydronic ASHP systems for North America (K. Nelson, personal communication, October 8, 2014).

Recommendations

Homeowners interested in using an ASHP as a retrofit to an oil-fired boiler with hydronic baseboard currently have two options:

1. Retrofit their baseboard heat emitters to ones designed for lower supply water temperatures and that fit within the design specifications of an appropriate air-to-water heat pump system. This retrofit may not be possible for all homes and is a process that requires a careful design by a qualified heating technician.
2. Install a ductless heat pump system and leave the hydronic system as redundant heating capacity.

Homeowners intending to build a new home that want to heat using an air-to-water heat pump should plan on appropriate in-floor or low-temperature baseboard distribution. This allows for the most flexibility in heating system choices and is generally recognized as best practice for efficient hydronic heating in residential buildings.

Given the uncertain timeline of further technology development in heat pumps and the consistent trend toward low-temperature hydronic for efficient residential heating, CCHRC does not anticipate high-temperature ASHPs will be available to U.S. homeowners in the near future.

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