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Heat Pumps Revolutionizing Retrofits: Scaling Up Deployment with Innovative Solutions and Overcoming Barriers

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Column

A Review of the Barriers that Remain Today for Heat Pump Widespread Deployment

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Heat pumps have been identified as the heating technology of choice for the efficient electrification and decarbonization of heating. They have been part of the toolkit of the HVAC industry for many decades, and their capabilities and potential applications are well known. However, their use is not yet fully widespread: This column explores some of the barriers that the industry still faces today.

The capital costs of heat pump systems, especially when compared to fuel-fired boilers or electric resistance heating, can represent a significant barrier to more widespread adoption. For example, the cost of a typical ground-coupled heat exchanger (with grouted vertical boreholes) is a major roadblock to overcome when projects enter the value engineering phase, and only about 10% of ground-source heat pump systems considered at schematic design survive the bidding process. While optimizing strategies can help, another possible answer to this is standing columns wells, a lesser-known ground-coupled heat exchanger technology with a significant presence in the New England region (USA). They can deliver the same thermal performance with reduced capital costs and a smaller footprint on the ground. These characteristics allow them to be successfully installed in dense urban areas (a notable example is New York, NY, USA). Consequently, they have been the subject of increased research over the last decade to develop more accessible design tools and to have a better understanding of their suitability, benefits, and limitations. These research initiatives are now bearing fruit, leading to greater awareness and an eventual increase in the adoption of the technology across North America.

Another barrier is found in cold, heating-dominated climates, such as those of Canada, northern USA, and Alaska. In these areas, commonly available air-source heat pumps tend to experience significant capacity and efficiency degradations at colder outdoor temperatures, limiting the energy and emission savings benefits of the technology. In certain regions, ambient temperatures may drop below the operating range specified by the manufacturer, further limiting system operations. Combined, these facts resulted in low seasonal operation and performance, making this technology much less attractive since supplemental heating is needed to handle the design heating load.

Fortunately, cold-climate heat pumps (CCHP) have recently become available and are gaining a significant market share with each passing year. While the initial design of CCHP resulted from various technology innovations implemented in large and small VRF systems, many air-to-air and air-to-water CCHPs are also benefiting from the advent of HFO refrigerants and the growing interest in natural refrigerants, which allow for even wider operating ranges and performance. Furthermore, in support of the development of these products, two recent US Department of Energy Cold Climate Challenges (the first for residential heat pumps, the second focusing on rooftop units) invited manufacturers to develop prototypes able to operate at even lower outdoor temperatures with high levels of performance. The first challenge concluded earlier in 2024, and participating manufacturers are already announcing new product lines based on the results. All in all, the availability of CCHPs in various configurations is steadily increasing worldwide, with many products now able to provide sufficient and efficient heating during most, if not all, of the heating season in non-arctic climates.

A third barrier for heat pumps is the lack of easy compatibility between heat pumps and some HVAC systems found in existing buildings. For instance, the hydronic heating systems of buildings in North America have historically been designed with a peak supply temperature higher than 80 °C, while 60 °C appears to be the norm for Europe. Most conventional heat pumps (e.g., those using R410A) are generally only able to provide significant volume of hot water up to about 45 °C, limiting the potential applications. As such, retrofitting heat pumps in buildings with high temperature hydronic distribution is generally impossible without some “design gymnastics”, for example, using the heat pump only when a loop operating conditions are reset to a low-enough supply temperature. An alternate strategy is thus to replace parts of the existing system (namely heating coils and space heating terminals) with units operating at temperatures more compatible with the one supplied by those heat pumps. However, such replacements are generally disruptive to building operations, often done at high costs, and thus only as part of deep retrofit projects. Today, with the research and development done in the field of high-temperature heat pumps for the industrial sector and, again, the advent of HFO refrigerants and natural refrigerants, a growing number of heat pumps offer the potential for direct “plug-&-play” into existing hydronic systems. High-temperature air-to-water models, with a maximum supply temperature of 60 °C available even at -20 °C outdoor temperature, and water-to-water models, able to achieve higher than 80 °C while producing chilled water, are now part of the standard product catalog of many large and small equipment manufacturers.

Following this review, we may wonder, “What barriers still remain?” An important one is a lack of general awareness of the broad range of products currently available, their capabilities, and the “new” potential applications. The dissemination of technical guidance and training for the selection, design, and operation of these systems, as well as the realization of demonstration projects and the publication of case studies, are critical activities that are currently picking up momentum. Within the IEA itself, various recent and current annexes of the HPT TCP aim exactly at achieving that. And we only need to look to the latest market news across the globe to see that trade journals, major equipment manufacturers, trade and technical associations, government agencies, and more are providing free webinars, publishing technical articles, guidance, and developing training on the electrification of heating with heat pumps. The conclusion is clear: The heat pump revolution is currently happening, but it is still in its infancy, and our continued efforts are needed to create lasting changes.

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