PRODUCT REVIEW

Commercial Heat Pump Water Heaters Using CO2 Refrigerant

Mitsubishi's Heat2O commercial heat-pump water heater uses CO2 as a refrigerant and is now available in the U.S.

by Brent Ehrlich

Heat pumps have become ubiquitous in our buildings because they are energy efficient and run on electricity rather than fossil fuels, an increasingly important consideration in areas where natural gas use is being restricted due to carbon emissions. The challenge is that the R-410a refrigerant typically used in heat pumps has a global warming potential (GWP) more than 2,000 times that of CO_2, and with U.S. regulations for these high-GWP gases looming, manufacturers are looking at low-GWP alternatives.

Mitsubishi is now offering its Heat$_2$O commercial heat-pump water heater, which uses carbon dioxide as a refrigerant. CO_2 (R744) is not the right refrigerant for every application, but with low flammability, low toxicity, and a global warming potential of only 1—a combination other refrigerants have a hard time matching—its use in Heat$_2$O offers us a glimpse of the potential future of commercial water heating.

The Heat$_2$O is engineered to maximize the performance of its low-GWP CO_2 refrigerant and withstand the higher pressures it requires.

Photo: Mitsubishi Electric Trane HVAC US

CO_2 goes mainstream

CO_2-based heat pumps are not new. Versions of Mitsubishi's CO_2-based heat pumps have been available overseas for more than 15 years, according to Cain White, director of commercial product management for Mitsubishi Electric Trane HVAC US (METUS). (BuildingGreen previously covered the Mayekawa and Sanden CO_2 heat pumps). Increasing demand from customers in the U.S. who want energy-efficient commercial hot-water systems that do not run on fossil fuels (combined with finalizing the extensive testing required to meet U.S. requirements) made the timing right for the company to bring the technology to the U.S. And using CO_2—which also has low toxicity and flammability—means the Heat$_2$O will meet future refrigerant restrictions.

In order for an HVAC system to maximize its efficiency, its refrigerant has to be optimized for the equipment and end use (for more on this see The Cost of Comfort: Climate Change and Refrigerants). A refrigerant for a residential mini-split will be different than one used in a large commercial chiller. CO_2 operates under very high pressures and is not the best solution for uses where you only need to raise the temperature a small amount (such as many space heating applications) or where the pressures would make piping and connections a challenge, said White. So you are not likely to see a CO_2-based air-source mini split or variable refrigerant flow (VRF) system. As White said, there are other refrigerants better suited for those uses.

CO_2 is an efficient refrigerant for domestic hot-water heat pumps, however. The Heat$_2$O is able to bring cool, incoming water up to 176˚F in one pass, and it is a self-contained outdoor unit that is engineered to withstand the pressures and optimize the use of CO_2. To maximize its efficiency, Heat$_2$O uses variable-speed compressors and pumps, and has six spiraled heat exchangers between the water and refrigerant. "This gives us extra surface area, so we get efficient heat exchange in a small footprint," said White. The result is a coefficient of performance (COP) of 4.11.

Load shifting and increased capacity

Another unique attribute of the HEAT$_2$O: it has built-in controls that make it capable of demand response—the ability to reduce stress on the regional electrical grid during peak hours of use. "With our product, a building can participate in load shifting," White said. It can potentially shed loads, reduce power consumption, increase capacity, adjust set points, or shut down. Residential electric water heaters currently have this ability through local utilities using a CTA-2045 connection (basically a port for a dongle), and it is now required in some regions, such as Washington and Oregon. But this is not yet a requirement for larger electric commercial systems.

The Heat$_2$O is modular, so up to 16 can be combined to allow capacities from 40 kW to 640 kW and can operate at 40-, 50-, or 60 kW (40 kW is the default energy-saving mode). Though there are no long-term performance data for the U.S. product, there are six pilot installations in process. The first of these involves retrofitting an aging electric boiler system in the Seattle Housing Authority's 100-unit Bayview Towers, a change that is expected to drop energy use from its current 106 kWh to 9.68 kWh.

According to Scott Spielman, P.E., with Ecotope, the engineering and research firm working with Mitsubishi on the project, a single Heat$_2$O serves the entire building and includes three large tanks that hold almost 1,000 gallons of thermal storage. "We used a third-party skid with the heat exchanger, QAHV [now called Heat$_2$O], and thermal storage," he said. This outdoor skid layout gives the system a compact footprint and makes it easy to install.

Ecotope's Bayview Towers system maximizes the efficiency of a CO_2-based Heat$_2$O by using the existing electric resistance storage as a swing tank. The Heat$_2$O heats the incoming 50˚F–60˚F municipal water to 150˚F; the heated water from this primary storage flows into the swing tank; and the swing tank recirculates the already-heated water and makes smaller adjustments to the water temperature when necessary to account for thermal losses. Over long periods of little use, such as overnight, the electric resistance will occasionally kick on, but the majority is done with the Heat$_2$O, according to Spielman.

Spielman claims the Bayview Towers system is the first large-scale multifamily project in the U.S. to use a CO_2-based heat pump for potable water and is the first to be used as a demand-response central hot water system. "We are going to be doing measurement and verification of the system performance over the next six months to a year for normal operation and demand response," he says.

The HEAT$_2$O is officially launching in the U.S. in August 2021 in select markets. Since it is a custom solution for each project, the company was unable to share cost data, but we'll update this article as more information and data are available.

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