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 Bryant D Hung

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 constrained due to carbon emissions. The challenge is that the use of a CO2-based refrigerant typically used in heat pumps has a global warming potential (GWP) more than 2,000 times that of CO2, and with U.S. regulations for high-GWP gases (150 or less) manufacturers are looking at low-GWP alternatives.

Mitsubishi is now offering its Heat2O commercial heat-pump water heater, which uses carbon dioxide as its refrigerant. CO2 (R744) is the right refrigerant for every application, but with low-flammability and low-toxicity, and a global warming potential of only 1—a combination other refrigerants have yet to achieve. R744 offers a glimpse of the potential future of commercial hot water heating.

CO2 Goes Mainstream

CO2-based heat pumps are not new. Vendors of Mitsubishi’s CO2-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 company’s R290 Heat2O system and its extensive testing required to meet U.S. requirements.) Due to carbon emissions, the R-410a refrigerant used in CO2 heat pumps 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-GW, 50-GW, 60-GW) base loads.

According to Sco Spielman, technology officer at METUS, the Heat2O system is very efficient, 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 main-line system will be different than one used in a commercial chiller. CO2 opens up 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 pressure would make piping and connections a challenge, said White. So you are not likely to see a CO2-based air-source mini split or variable refrigerant flow (VRF) system. As White said, there are other refrigerants better suited for those uses.

CO2 is an efficient refrigerant for domestic hot-water heat pumps. However, the Heat2O is able to bring cool, incoming water up to 150°F in one pass, and is a self-contained unit that is engineered to withstand the pressures and optimize the use of CO2. To maximize its efficiency, Heat2O use variable-speed compressors and pumps, and has six spiral 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 4.1 to 4.11.

Load Shifting and Increased Capacity

Another unique attribute of the Heat2O is that it has built-in controls that make it capable of demand response—the ability to reduce energy use 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 Heat2O’s module, up to 16 in, is able to combined to allow capacities from 40 kW to 640 kW and can operate at 40-, 50-, or 60-kW (40-GW, 50-GW, 60-GW) base loads. According to Scott Spielman, E.T., with Entropic, the engineering and research firm working with Mitsubishi on the product, a single Heat2O serves the entire building and includes three large tanks that hold almost 24,000 gallons of thermal storage. "See integration of commercial heat pump with the heat exchanger; QAHV have called Heat2O, and thermal storage," he said. This outdoor shell layout gives the system a compact footprint and makes it easy to install. Entropic’s Bayview Towers system maximizes the efficiency of a CO2-based Heat2O by using the existing electric resistance storage as a energy bank. The Heat2O has the incoming on-site 47°F municipal water to 165°F, the heated water from the 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 typically kick on, but the majority is done with the Heat2O, according to Spielman.

Spielman claims the Bayview Towers system is the first large-scale multifamily project in the U.S. to use a CO2-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 do measurement and verification of the system performance over the next six months to a year for normal operation and demand response," he says. The Heat2O is officially launching in the U.S. in August 2021 in select markets. Stetsy 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.

The Heat2O is engineered to maintain the performance of R-1234YF refrigerant and achieve higher energy improvements. Photo: Mitsubishi Electric Trane HVAC US

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