PRELIMINARY TECHNOLOGY ASSESSMENT – SEPTEMBER 2022

CO_2-Based Heat Pump

Technology Overview

Decarbonizing heating systems is key to achieving net zero. Thirty-two percent of U.S. energy is supplied by natural gas, contributing to 34% of annual CO_2 emissions.[1] The CO_2-based heat pump increases heating and cooling efficiency by capturing and reusing thermal energy. Heat pumps use electricity and a refrigerant to transfer heat inside when it is cold (heating) and outside when it is hot (cooling). In extremely cold weather (< 32°F), conventional heat pumps become less efficient by working harder to extract freely available thermal energy from the surrounding environment. This CO_2-based heat pump does not rely on outside air temperature and works efficiently in both hot and cold weather. It can also provide simultaneous heating and cooling. Most contemporary cooling systems use high global warming potential (GWP) hydrofluorocarbons (HFCs) as the refrigerant. The GWP of HFCs is 1,000 to 4,000 times more powerful than CO_2, and the Biden-Harris Administration is committed to phasing them out.[2] This CO_2-based heat pump uses carbon dioxide as an inexpensive, non-toxic, non-flammable, and low-GWP refrigerant. Using CO_2 enables the highly efficient recovery of heat from air, water, or thermal waste streams and allows the pump to cool down to-22°F and heat up to 250°F. Commercial heat pumps are often large and require both indoor and outdoor components. This CO_2-based heat pump requires no outdoor space and has a compact, modular design that maximizes space in technical and mechanical rooms and between existing equipment. It requires minimal monthly maintenance and a single annual full-service shutdown. Operation is facilitated with real-time monitoring.

Why is GSA Interested?

To evaluate the net-zero potential in a real-world setting, GSA-owned facilities provide the testing ground for clean-energy technologies. The manufacturer claims that this CO_2-based heat pump is seven times more efficient than conventional heating and cooling systems (i.e., boilers, electric heaters, and chillers). It decarbonizes heat with a combustion-free process and without burning fossil fuels, reducing emissions, energy use, and GWP. It also requires less makeup water than traditional heating and cooling systems. Its smaller profile reduces the space required in industrial facilities, data centers, mechanical rooms, and other similar spaces.

How Will Success Be Measured?

The testbed will assess three key manufacturer claims: 60% heating and cooling savings, payback in less than 8 years, and minimal maintenance.

Deployment Potential

This heat pump is climate agnostic and has a modular design suitable for retrofits and new construction. It will have the best return on investment for humid climates and buildings that use simultaneous heating and cooling.

[1]U.S. Energy Information Administration, https://www.eia.gov/energyexplained/energy-and-the-environment/where-greenhouse-gases-come-from.php, accessed 05-2022.
[2]Fact Sheet: Biden Administration Combats Super-Pollutants and Bolster Domestic Manufacturing with New Programs and Historic Commitments, https://www.whitehouse.gov, accessed 06-2022.

U.S. General Services Administration (GSA), in collaboration with the U.S. Department of Energy, is evaluating the real-world performance of CO_2-based heat pumps in federally owned buildings within GSA's inventory. The technology will be provided by Dalrada and coordinated with other ongoing evaluations of this technology.