Mechanical Business

MAGAZINE HVAC

Inverter technology offers emissions and efficiency benefits

By **MechBiz** On **Nov 8, 2023**

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As the impacts of climate change become more apparent, corporations and regulators are doubling down on efforts to decarbonize. For business leaders and building operators looking to make a difference, it is imperative to explore innovative and energy-efficient HVAC systems. Enter the inverter heat pump: a solution that offers numerous benefits for commercial buildings.

At their core, heat pumps work in much the same way as an air conditioner, using refrigerants to move heat from one place to another. But instead of moving heat out of the building and into the air, heat pumps do the opposite, capturing heat from the air and moving it into the building. Heat pumps have been used successfully for decades, but up until recently, their use in commercial buildings has been limited in North America

GAINING EFFICIENCY WITH INVERTERS

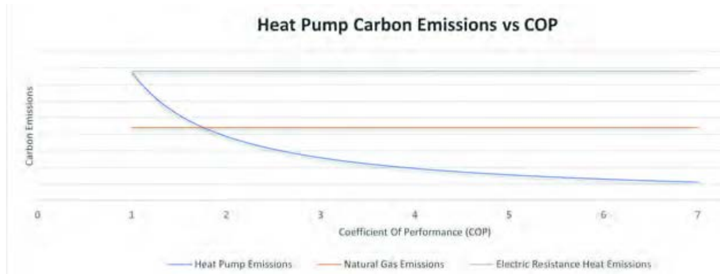
Traditional air conditioners and heat pumps operate on a fixed-speed compressor system, which means they run at a constant speed regardless of the heating or cooling requirements. Inverter heat pumps, in comparison, use variable-speed compressors and can adjust the output to match the specific needs of the building, resulting in enhanced efficiency during part-load operation. Since heat pumps (and most HVAC equipment) spend the majority of their time operating at part-load conditions, enhancing efficiency yields substantial results. In addition to energy efficiency, inverter heat pumps have other benefits for commercial buildings, including increased comfort, temperature and humidity control, and noise reduction.

ELECTRIFYING ROOFTOP UNITS

Given their prevalence, natural gas-powered packaged rooftop units (RTUs) – the most frequently used applied HVAC equipment – are an ideal fit for inverter heat pumps. Although roof curbs and electrical feeds may need to change, most inverter heat pump RTUs can fit into the same physical space as traditional gas-fired units. This offers an easier path to conversion.

There is one notable challenge in moving from natural gas to heat pumps, however, and that is cold climate operation. As it gets colder outside, the ability of a heat pump to deliver heat is reduced while the building's heating demand increases. Eventually, the heat pump reaches a "crossover point" where the heating demand is greater than the system's available capacity and some form of auxiliary heat must be used. Often, this supplemental heat comes in the form of electric resistance heating, which is more energy intensive. Inverter heat pump RTUs do have an advantage in these situations, though. The compressor can be ramped up to higher maximum speeds to improve capacity, which aids in moving the crossover point to a lower ambient temperature. Although inverter heat pumps often have a higher upfront cost compared to traditional heat pumps due to their advanced technology, the energy savings and efficiency gains can lead to a quicker return on investment, especially in regions with higher utility rates.

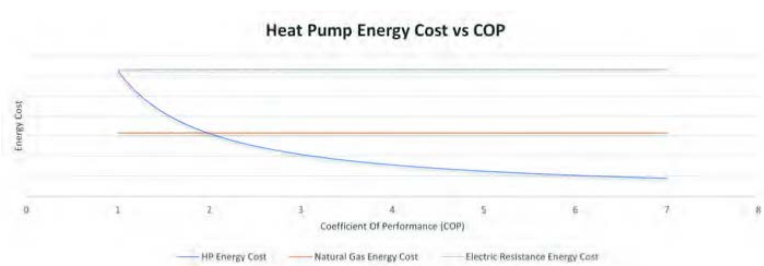
CONTRIBUTING TO DECARBONIZATION



By electrifying a building's heat source, inverter heat pumps reduce direct carbon dioxide (CO_2) emissions at the facility level. But the efficiency at which the heat pump becomes more carbon friendly varies when both the building and grid are considered.

Figure 1 shows an example of this effect. It approximates the emissions for both natural gas and electricity for a non-specific electrical grid assuming a grid emission factor of 387 grams per kilowatt-hour, which describes the overall cleanliness (the carbon emissions tied to creating electricity) of the electrical grid. CO_2 emissions of heating with natural gas are plotted in orange. In grey, we see the emissions of electric resistance heat. Comparing the two, we see that electric resistance heat has higher CO_2 emissions than direct natural gas heating due to the fossil fuels used to generate the electricity.

We then add the heat pump emissions in blue, which vary as the efficiency of the heat pump varies. In conditions where the heat pump can run with a higher coefficient of performance (COP), the emissions can be less than natural gas. As the outdoor ambient temperature drops and the COP of the heat pump drops below approximately 1.8, the emissions increase above natural gas. Of course, the actual value will vary depending on the specific electrical grid.



By increasing the overall efficiency of the heat pump and improving the low-ambient performance, inverters improve the average efficiency of the unit and make it more advantageous from an emissions perspective. Just as there is a crossover point for carbon emissions, the same is true if we map out energy costs, as shown in Figure 2. Depending on the location and corresponding cost of electricity and natural gas, as the heat pump COP improves so do the operating hours where the heat pump is less expensive to operate. It is important to note that the COP crossover point for operating costs may be different than the crossover point for emissions. Design goals become important in determining what level of COP should be specified.

Overall, the more efficient the heat pump is, the greater the number of applications and locations it can provide an emission and/or energy cost advantage. Inverters serve a double benefit of improving efficiency and improving operation during cold conditions, which is when HVAC performance often tends to decline, lessening the operating hours for more costly electric resistance backup heat.

CONSIDERATIONS FOR INSTALLERS AND DESIGNERS

Adopting inverter heat pumps requires careful and practical attention to a range of factors.

- Design Goals: Design is important to specify equipment that will meet the site needs and efficiency standards. Questions to ask: Are there regulatory drivers or corporate carbon emissions targets at play? And do those targets apply at the building level or include indirect grid emissions as well?
- Sizing and capacity: Accurate sizing is essential when considering inverter heat pumps. It is important to assess the building's heating and cooling loads, and ambient extremes when selecting a unit. As ambient temperatures drop, the benefits of inverter compressors become pronounced versus fixed-speed units, though even mild climates can benefit from the efficiency of inverter technology.
- Maintenance and service: As with any HVAC equipment, regular maintenance is key to longevity. Contractors should establish a consistent maintenance schedule to clean filters, inspect coils and verify refrigerant levels.

Many inverter systems also feature advanced diagnostics that empower proactive maintenance and prevent costly disruptions.

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