NAVIGATING THE HEAT PUMP JUNGLE

Understanding that heat pumps are one of the only machines in the industry that can deliver more energy than they consume, can clarify the push to this efficient option.

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Heat pumps have buzz, and that buzz is likely to continue based on their efficiency and rebate incentives, so let's understand why they are important and how to correctly install them. Heat pumps are not new to the HVAC market and have been commercially used since the 1970s. Heat pumps were primarily used in areas with short and mild winter seasons, such as the Southern, Southeastern, Southwestern, and Western regions of the United States, because the performance of these systems at the time degraded significantly as the outside air temperature dropped. As a result, their use was restricted in areas with colder climates.

With climate change and high inflation concerns, the federal government is incentivizing the widespread use of heat pumps. This article will discuss why the federal government targets heat pumps and what has changed with the technology. We will also discuss the new HVAC market sector of cold-climate heat pump technology and some design guidance on how heat pump systems should be installed and commissioned.

How the heat pump works

The heat pump utilizes a mechanical vapor compression system to move heat from one location to another. It reverses the flow of refrigerant in the heating mode to repurpose the indoor AC evaporator to a condenser, which rejects the heat to the building space. When the system is changed to the heating mode, the outdoor AC condenser becomes the evaporator absorbing heat from the outside ambient air. This is possible because the refrigerant in the outdoor coil is a temperature lower than that of the ambient. Because the outdoor coil is operating below 32°F, the outdoor coil will often need to go into defrost mode to clear the ice from the coil. This is necessary because the performance and capacity of the heat pump drops as ice collects on the outdoor coil. The reversing valve and specialized metering devices allow the heat traditional air conditioner to be converted to a heat pump.

Historic federal funding

Heat pumps have gained a renewed focus due to the federal funding of the Inflation Reduction Act, a bill that the U.S. Congress passed in 2022. This bill provided massive federal support for the installation of heat pumps because of their energy-efficiency (both good for the climate and for American wallets) and potential for massive climate impact. This includes $400 billion dollars to support clean energy projects to address climate change, $8.8 billion of which is earmarked for home energy rebates for energy efficiency and electrification projects. This bill also has provisions for additional incentives, such as federal tax credits for qualifying energy retrofit projects. For qualified electrification projects, homeowners can get considerable monetary support from rebates and tax credits to help them invest in electrification measures.

Electrification replaces nonelectric appliances, i.e., combustion appliances, with appliances that consume electrical power to achieve their purpose. A prime example of an electrification project is to replace an existing air conditioner with an air source heat pump. Examples of other qualified efficiency measures include: increasing attic insulation, professional building air sealing, heat pump water heaters and electric vehicle chargers.

Why electrification is important

Electrical power is a highly regulated commodity. All commercially produced electrical power has some form of regulation to ensure that electrical power is clean and reliable. From power plant emissions to power distribution, electricity continues to become cleaner and cleaner. In contrast, very few locations in the U.S. have regulations for combustion appliances, and the emissions from combustion appliances can go unchecked for decades. Heat pumps have one distinct advantage: they are one of the only machines in our industry that can deliver more energy than they consume, making them more than 100% efficient. This is because a heat pump moves heat instead of generating it.

Heat pumps have a few rating that the HVAC professional and the general public need to understand when evaluating their performance. One commonly used rating is the Coefficient of Performance (COP). The COP is the ratio of useful heating or cooling output to the amount of energy consumed. The higher the COP number is, the more efficient the heat pump is. Another performance metric often used to select heat pumps is the Heating Season Performance Factor (HSPF). This rating expresses the ratio of heating output to electricity consumption over a typical heating season. The same rule applies to the HSPF, the higher the number, the more efficient the heat pump is.

Heat pumps have a significantly lower carbon footprint than a gas furnace. Studies from the National Resources Defense Council (NRDC)[1] have shown that heat pumps can reduce carbon emissions by 40%–70%. With the dual benefit of energy efficiency and reduced carbon emissions, there is a large push for overall HVAC market transformation for heat pumps to replace air conditioners.

Contractor resistance

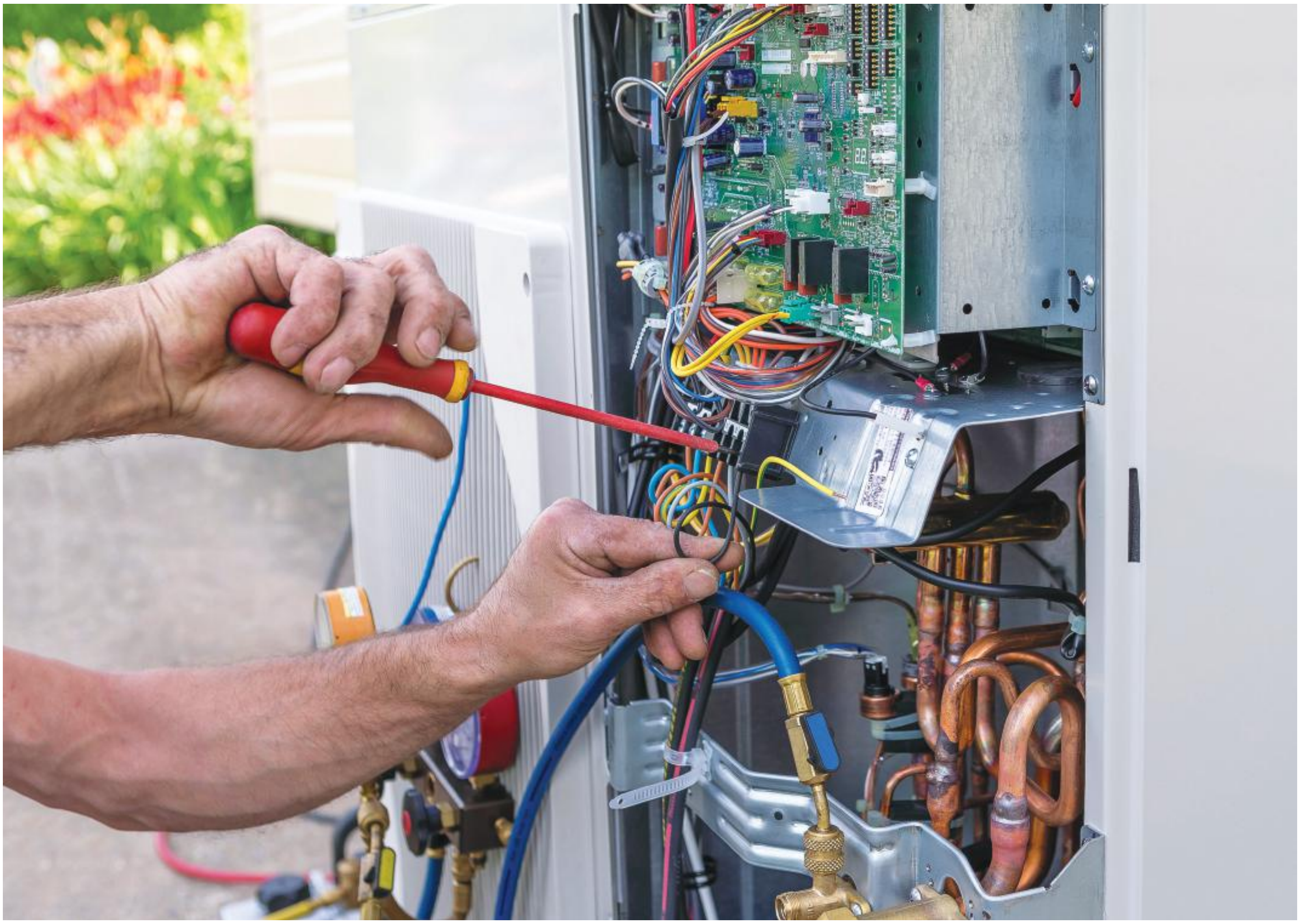
So, why have heat pumps not been more common in the colder regions of the U.S.? Traditional heat pumps also had some disadvantages. As the outside ambient temperature decreased, so did the heat pump's capacity and efficiency. With poor cold weather performance and high heating loads, the systems could not satisfy the space heating requirements in cold climates. A misapplied heat pump in a cold climate would run continuously, and the homeowner would be surprised with a huge utility bill. Heat pumps also have significantly lower discharge temperatures than combustion heating appliances. Client education on operation is critical, and the customer needs to be made aware of the cooler discharge temperatures of heat pumps and to prevent the customer from placing unnecessary service calls.

A tight building shell ensures that a heat pump can be used practically in a cold climate. In this case and in areas with an older housing stock, the heating capacity required to keep the building comfortable may be too large for even the largest heat pump. A customer can unknowingly request a heat pump from a contractor in reaction to various marketing campaigns without first requesting weatherizing the building envelope. Customers will quickly find out that the heat pump cannot keep up with the heating demand.

Due to the cold climate disadvantages of traditional heat pumps, contractors have been conditioned to discourage using a heat pump in these areas, even if the homeowner is looking to purchase one for personal reasons such as combating climate change. Contractors have resisted installing heat pumps to date because they do present unique challenges (despite their obvious benefits). The HVAC contractor market is competitive, and a poor customer experience could be costly. Contractors fear a loss in revenue from callbacks and a damaged reputation.

Cold-climate heat pumps

Heat pump technology has improved tremendously throughout the years. Now, we have a cold climate-rated heat pump specifically designed to deliver all or nearly all of its rated capacity at extremely low temperatures, like -5°F. Manufacturers achieve these ratings with a few design adjustments, one of which includes using larger inverter-driven compressors to control their speed closely. If you control the compressor's speed, you can control the heat pump's capacity. In addition to being inverter driven, compressors are oversized compared to traditional heat pumps. For example, a 2-ton cold climate compressor may have a 3-ton compressor inside. Heat pumps also have precision control metering



devices and fans that also work to deliver their rated capacity in cold temperatures.

Design considerations

Regardless of the style of heat pumps or design approach, the fundamental HVAC design process remains the same: heat loss/heat gain load calculations, equipment selection and duct design. Here are some ways to approach heat pump installations to ensure good outcomes.

A heat loss/heat gain load calculation such as a *Manual J* from Air Conditioning Contractors Association (ACCA) will calculate the required Btuh requirements of the dwelling. Remember, with an older housing stock, the Btuh requirements may be too large even for the largest heat pump. To reduce the load and to make the heat pump a practical option, the dwelling may need some weatherization work done to bring the building load down enough for a heat pump to maintain the building setpoint.

Equipment selection is another critical piece of the design process. Engineering manuals like ACCA's *Manual S* guides designers on how to select heat pump systems properly. For a cold climate-rated heat pump that modulates, it is recommended that the heat pump selected does not exceed the cooling load by more than 30%. If the heat pump is grossly oversized for the cooling load, supplemental dehumidification is recommended because the oversized load for the air conditioner does not have the runtime to handle building moisture effectively. If moisture is not controlled, biological growth and potential building damage via durability issues can result.

Proper duct design is another design consideration for proper heat pump operation. Heat pumps require more air than combustion appliances or air conditioners. A duct modification may be required for the heat pump to operate properly. Guidance found in ACCA's *Manual D* helps the HVAC designer size and design the duct system so that the conditioned air from the heat pump can be delivered to the occupied spaced effectively.

Heat pump implementation options

There are three ways to apply heat pump technology to an existing building when planning for heat pump retrofits. The first method of installation to consider is a heat pump sized to the building heating load with no backup capacity. For this method to work, a tight building envelope is essential to keep the heat pump within its capacity and efficiency limits. Before any contractor uses this approach, it is advised that the customer invests in the building envelope, such as attic insulation and professional air sealing. An adequately rated cold climate heat pump is needed for this installation method. Also, customers need to be made aware of the risk if the heat pump fails as there would not be any backup or supplemental heating support.

Another option is to use the heat pump with auxiliary or supplemental heating. This is a fairly popular method that has been used for many years, and a backup heat source makes up the difference if the heat pump cannot solely service the heating load. The building has auxiliary or supplemental heat that can supplement the capacity when the weather is outside the design conditions or when the heat pump has gone into a defrost cycle. The supplemental heat can also be used as an emergency heat source if the heat fails and needs repair.

The last option is a dual-fuel or hybrid heat source. This approach uses a combustion appliance as a backup source of heat. The heat pump is sized to the cooling load or a portion of the heating load, and an appropriately sized forced air furnace is used in the event of extremely cold weather. This system will operate the heat pump in milder conditions and then shut down at a predetermined temperature. This temperature could be a setpoint calculated based on the economics between electrical consumption and the cost of the backup fuel.

This arrangement is called the "economic balance point." The setpoint can also be based on the setpoint temperature that the heat pump cannot maintain. This temperature is known as the "thermal balance point." The decision to use either of the two settings depends on the climate region, fuel cost and the heat pump's capacity. The dual fuel options are a favorite among many contractors. Customers can electrify their homes and realize energy savings by using the heat pump for milder conditions and using the combustion appliance in colder design conditions.

Conclusion

It is safe to say that heat pumps have come a long way, in sustainability as well as technologically and economically. As long as installers do their due diligence when selecting, sizing and installing this type of system, and properly explain the basics to their customers, heat pumps can satisfy a variety of requirements for the business and building owners, alike.

References

1. National Resources Defense Council (NRDC), "The Climate Math of Home Heating," www.nrdc.org.

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