COOLTHERM
AIR CONDITIONING REFRIGERATION

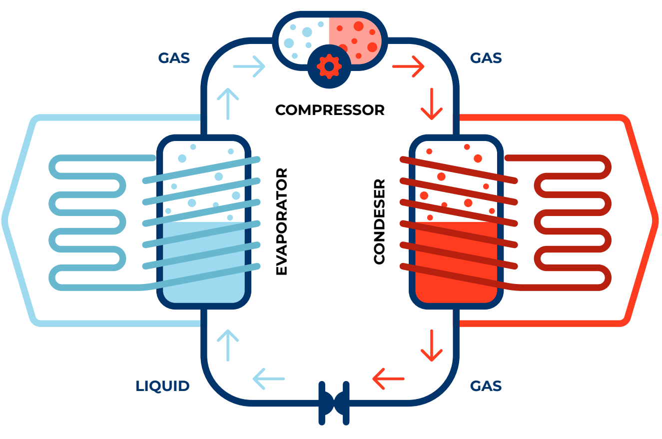
HOW DO HEAT PUMPS WORK

As energy efficiency and sustainability have become imperative for businesses to operate economically and ethically, a reduced reliance on combustion-sourced heating is essential. Heat pumps will, therefore, inevitably play a crucial role in modern heating and cooling systems.

All heat pumps operate on the same fundamental principle: heat transfer. Unlike traditional heating systems that burn fuel to generate heat, heat pumps move heat from one location to another. This process is grounded in the laws of thermodynamics, which dictate that heat naturally flows from high-temperature areas to low-temperature areas.

Reversing the Flow of Heat

By using a small amount of energy, heat pumps can extract heat from a relatively cool area and transfer it to a warmer one. This is achieved by leveraging the properties of refrigerants, which can absorb and release heat efficiently. Essentially, heat is moved from a heat source, such as the ground or outdoor air, into a heat sink, such as an office room.



AIR-SOURCE HEAT PUMPS

One of the most common types of heat pumps is the air-source heat pump. These systems extract heat from the outdoor air and pump it indoors using refrigerant-filled coils, similar to the mechanism found in the back of a refrigerator – but in reverse. The basic components of an air-source heat pump include two fans, refrigerator coils, a reversing valve, and a compressor.

How Air-Source Heat Pumps Work

In heating mode, an air-source heat pump absorbs heat from the outside air through the outdoor coil. The refrigerant inside the coil captures this heat and becomes a high-pressure, high-temperature vapor. This vapor is then compressed further to increase its temperature and is directed indoors. Inside the house, the refrigerant releases its heat as it condenses back into a liquid, warming the indoor air. The cooled refrigerant then returns outdoors to absorb more heat, and the cycle continues.

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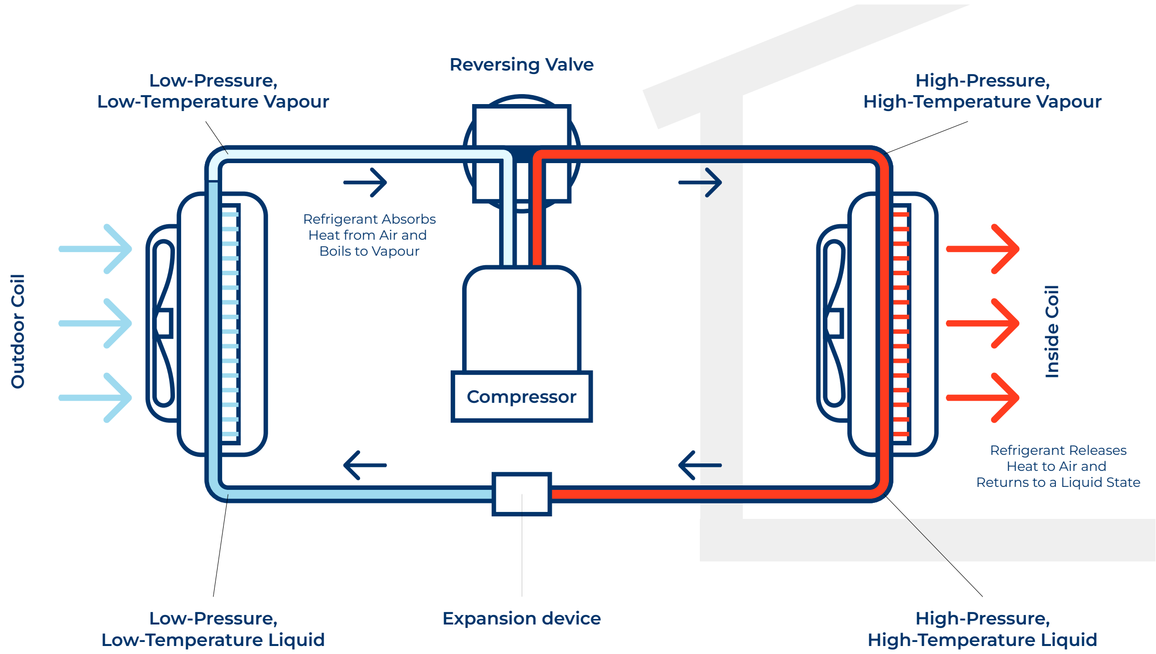
The Reversing Valve: Key to Dual Functionality

The reversing valve is a critical component that allows air-source heat pumps to function as both heaters and coolers. This valve changes the direction of the refrigerant flow, enabling the system to switch between heating and cooling modes. In cooling mode, the process is essentially reversed. The refrigerant absorbs heat from the indoor air and carries it outside, where it releases the heat and cools down before returning indoors to pick up more heat. This cycle repeats until the desired indoor temperature is achieved.



GROUND-SOURCE HEAT PUMPS

Unlike air-source heat pumps, ground-source systems leverage the relatively constant temperatures found underground. They absorb heat from the ground or an underground body of water and transfer it indoors during winter, whilst reversing the process in summer and providing cooling.

How Ground-Source Heat Pumps Work

The most common type of ground-source heat pump transfers thermal energy directly from the ground via buried pipes filled with refrigerant. These pipes can be configured in either a closed-loop or an open-loop system.

In a closed-loop system, the refrigerant continuously circulates through a series of buried pipes in the building's grounds.

Open-loop systems operate by pumping water directly from an underground source, such as a well or a lake. The water is brought to the heat pump, where heat is transferred. After transferring its heat to the refrigerant in the heat pump, the now-cooled water is returned to its original source.

ABSORPTION HEAT PUMPS

Absorption heat pumps are another innovative type of heat pump that operate differently from conventional air-source heat pumps and are best suited for large-scale applications.

These systems can be powered by various energy sources, including natural gas, solar power, propane, or geothermal-heated water, instead of electricity.

How Absorption Heat Pumps Work

The primary difference between standard air-source heat pumps and absorption heat pumps lies in their action mechanisms.

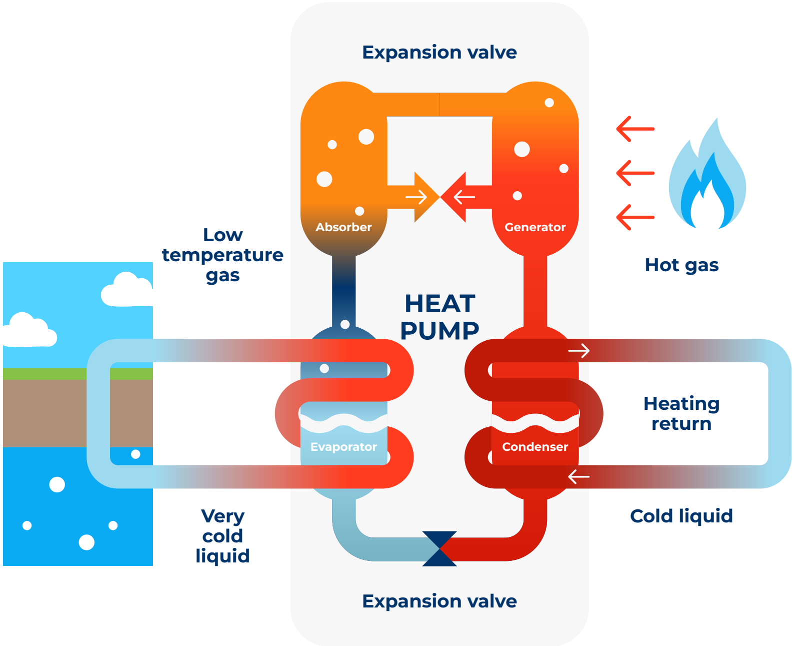
Instead of compressing a refrigerant, an absorption heat pump uses a process involving ammonia and water.

The cycle begins with ammonia being absorbed into water. This ammonia-water solution is then pressurised by a low-power pump. The heat source then boils the ammonia out of the water. The ammonia vapor absorbs heat from the environment and then re-condenses, restarting the cycle.

Rating and Efficiency of Absorption Heat Pumps

When evaluating absorption heat pumps, it's essential to understand their efficiency ratings, measured by the Coefficient of Performance (COP). The COP indicates how effectively the heat pump converts energy into heating or cooling.

Ground-source and absorption heat pumps offer unique and efficient alternatives to traditional heating and cooling systems. Ground-source heat pumps leverage the stable temperatures underground to provide reliable and efficient heating – and cooling.



NON-TRADITIONAL HEAT PUMPS

Air and ground source heat pumps are by far and away the most common – and well-known – variation of heat pump technology. That does not mean, however, that they are the only version available.

Reverse Cycle Chiller (RCC) Systems

As we have seen, commonly heat pumps rely on air to transfer heat. Reverse cycle chillers use water instead.

This design can operate more efficiently in reduced temperatures. An RCC system connects to an insulated water tank, which the heat pump either heats or cools. A fan and coil system then distributes the heated or cooled air from the tank through the ductwork to one or more 'heating zone'.

RCC systems can also pump hot water through radiant floor heating systems, offering another solution for cold climates. In these systems, the hot water from the tank can also be used to defrost the coils, eliminating the need for auxiliary warming equipment. Therefore, the system will not blow cold air during the defrost cycle, maintaining consistent warmth.

Cold Climate Heat Pumps

Cold climate heat pumps are a newer addition to the suite of heat pumps, designed to handle extremely cold weather – efficiently operating even in temperatures below -18°C. These heat pumps are equipped with technology that detects the minimum amount of energy required to provide the desired level of heating or cooling, adjusting their output accordingly to avoid energy waste.

WHAT TO LOOK FOR IN A HEAT PUMP

There are several key factors to consider when sourcing the most efficient and cost-effective heat pump for your application.

Manufacturers rate the efficiency of heat pumps using two primary metrics: SEER and HSPF ratings. Higher ratings in both categories indicate a more efficient unit.

SEER, which stands for Seasonal Energy Efficiency Ratio, measures the cooling efficiency of the heat pump. It is calculated as the ratio of the cooling output (measured in BTUs) to the electricity consumed (measured in watts). For optimal efficiency, look for a SEER rating between 14 and 18.

HSPF, or Heating Seasonal Performance Factor, measures the heating efficiency of the heat pump. It calculates the ratio of the total space heating required during the 'heating season' to the total electrical energy consumed, accounting for supplemental heating needs and defrosting. An efficient heat pump should have an HSPF rating between 8 and 10.

Many heat pumps come with additional features designed to enhance their efficiency and longevity. These features can justify the higher upfront costs through long-term energy savings. One such feature is a desuperheater coil, which heats water by recycling waste heat. In RCC systems, a refrigerant heat reclaimer uses the pump's extra capacity to heat water during milder weather.

Dual-mode compressors and motors, which adjust based on the heating or cooling demand, also save energy by scaling up or down as needed.

And scroll compressors, known for being quieter and more efficient, tend to last longer than alternative traditional compressors.

While many of these advanced features are found on more expensive models, they can offer significant energy savings over the life of the heat pump. The initial investment can be offset by lower operating costs, making these features a worthwhile consideration.

Knowing what to look for in a heat pump, including efficiency ratings and advanced features, can help you make an informed purchase that balances upfront costs with long-term savings. So, the next question is, will a heat pump really save you money? By selecting a high-efficiency unit with beneficial features, you can significantly reduce your energy bills whilst reducing total emissions.

INSTALLATION EFFECT ON PERFORMANCE

The benefits of a heat pump hinge significantly on its installation quality. Improper installation can severely impact the efficiency of a heat pump, undermining its performance and potential savings. A poorly installed heat pump may fall short of any efficiency benchmark and quickly erode any expected savings.

This underscores the importance of selecting a reliable heat pump installer. A good installer not only ensures proper fitting but can also advise on necessary energy efficiency upgrades to keep upfront costs manageable.

Ran Boydell, an associate professor at Heriot-Watt University, emphasises, "if a heat pump doesn't perform effectively in cold weather, chances are the unit was incorrectly specified for the location."

Several factors are critical during installation to ensure optimal performance. Proper airflow is essential for a heat pump to function efficiently.

Restricted airflow can cause the system to work harder than necessary, reducing its overall efficiency.

The correct refrigerant level is also crucial, as too much or too little refrigerant can impair the heat pump's ability to transfer heat, negatively impacting the COP (Coefficient of Performance). Refrigerants with low ozone depletion potential (ODP) and global warming potential (GWP) can enhance COP values, making the system more environmentally friendly and efficient.

Additionally, the design and installation of ductwork play a significant role in efficient air distribution throughout the building. Poorly designed ductwork can lead to energy losses and reduced system efficiency.

Furthermore, the overall design of the heat pump system, including the type of compressor and heat exchanger, is crucial for determining its efficiency. Well-designed systems will maximise heat transfer capabilities and boost COP.

It is clear, therefore, the efficiency of a heat pump is heavily dependent on its installation. Choosing a reputable installer and ensuring proper installation practices will make a significant difference in the system's performance. By paying attention to airflow, refrigerant levels, ductwork design, refrigerant choice, and system configuration, building owners will achieve higher efficiency, lower operating costs, and reduced environmental impact. Proper installation not only helps realise the full benefits of a heat pump but also secures recognisable savings and improved sustainability.

Heat pumps offer several advantages over traditional heating and cooling systems. They are more energy-efficient because they move heat rather than generate it, leading to lower energy bills and reduced environmental impact.
With understanding of the basic operation and benefits of heat pumps, more informed decisions about potential equipment purchase can be made. Whether you opt for an air-source heat pump or another type, these systems provide an efficient, eco-friendly way to direct heat wherever it is needed.

To receive expert advice on heat pumps for your business's application, contact Cooltherm. We have over 30 years' experience working in HVAC systems across the UK, and we are available to support you on whatever heat pump information you require.

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