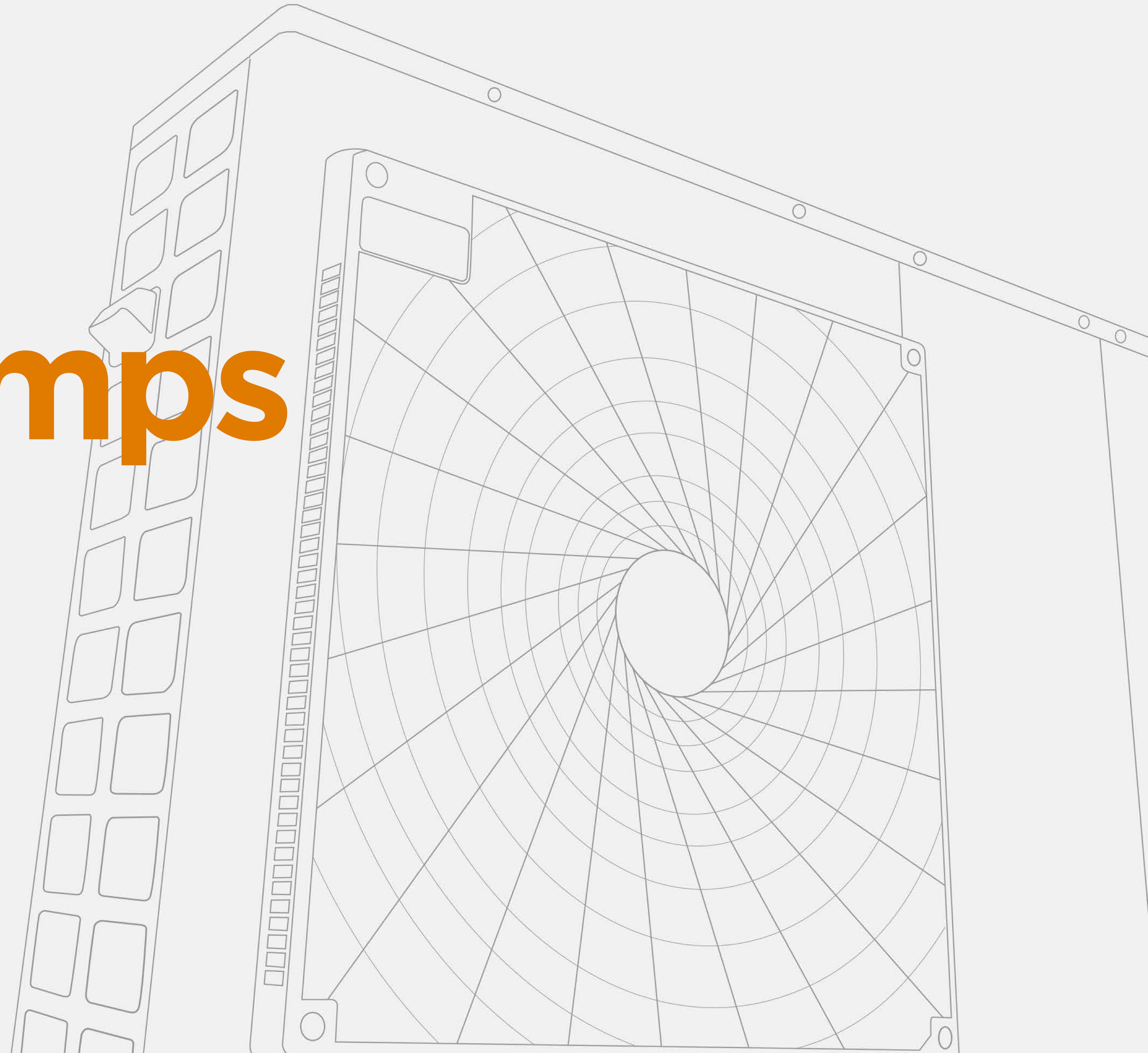
Ahead of the Expected

LG

The Future of Heating and Cooling: Heat Pumps



Heat pumps offer economic and environmental advantages through efficient and effective operation. This white paper explores how heat pumps work and the benefits they provide.

Heat Pump Whitepaper Contents

Introduction

Heat pumps have garnered attention across the HVAC industry as effective heating solutions that conserve energy, reduce heating costs, and lessen the impact of HVAC systems on the environment. These solutions are able to achieve higher energy efficiency by utilizing small amounts of electricity to transfer heat energy as opposed to generating all the required heat themselves. This efficiency makes heat pump technology even more significant when it comes to the protection of the environment. In particular, the eco-friendly facet of these solutions stands out in light of the growing importance of reducing greenhouse gas emissions and mitigating the impact of climate change.

While heat pumps provide important advantages over conventional heating systems, there is a long way to go before they achieve widespread adoption. Some of the challenges they have faced in the market are high upfront costs, technical limitations in extreme conditions, and the necessity for proper sizing, installation, and maintenance. However, the latest technological developments in the space and support from local government policies are breaking down these barriers.

In this whitepaper, we will explore the basics of heat pump technology, how heat pumps work, and the advantages heat pumps provide over conventional heating solutions.

What is a Heat Pump?

To begin with, we must answer the question, ‘What is a heat pump?’ To put it simply, heat pumps are devices that use a small amount of energy to transfer heat from one place to another.[1)]

They achieve this transfer of energy that’s unused in nature into usable heat via the refrigeration cycle. Heat pumps fundamentally operate as air conditioners but the refrigerant cycle can be reversed to provide heating and cooling. When used for heating, heat pumps extract heat from ambient outdoor air, the ground, or water and transfer it indoors. Alternatively, they remove heat from indoors and release it outside to provide cooling.

The ability of heat pumps to transfer more heat energy than the electrical energy consumed in the process makes them highly efficient solutions. In fact, they can extract as much as 75% of the energy they consume from ambient air, geothermal, or water heat sources.[2)]

Fundamental Components and What They Do

In order to understand how heat pumps work, we must first know what goes into a heat pump to begin with. Let’s take a look at the core components of a heat pump to better understand the cycles of heat pumps and how they operate.

Evaporator

The evaporator acts as a heat exchanger in the refrigeration cycle of a heat pump. It absorbs heat from ambient air outdoors and transfers that heat into a liquid refrigerant. Through this process, the refrigerant is converted from a cool liquid into a warm gas. The primary function of the evaporator is to absorb heat and transfer it to a medium that can be moved through the heat pump system.

Compressor

The compressor is an essential component in the refrigeration cycle of a heat pump. It is responsible for compressing low-pressure, low-temperature refrigerant, which increases its temperature. Some heat pumps use inverter compressors that operate at variable speeds and deliver higher efficiency.

Condenser

The function of the condenser is to cool and condense a high-pressure, high-temperature refrigerant back to a liquid state, and enable it to repeat the cycle.

Expansion Valve

The expansion valve is positioned between the high-pressure and low-pressure sides of a heat pump system and controls the flow of refrigerant between the 2 sides. It reduces the pressure of the refrigerant as it moves into the evaporator and, in turn, causes that refrigerant to evaporate. The evaporated refrigerant can then absorb heat from the air around the system.

The functions of these components are closely tied together and allow heat pumps to provide both heating and cooling. Let's take a look at both the heating and cooling cycles of a heat pump to further understand the technology.

How Does a Heat Pump Work?

Generally, heat pumps can be categorized according to the heat source implemented in the system. The 3 main types of heat pump are air-source, geothermal, and water-source. Although we will touch on each of these 3 types of heat pump later in this whitepaper, we will primarily focus on air-source heat pumps as they are the most common type of heat pump.

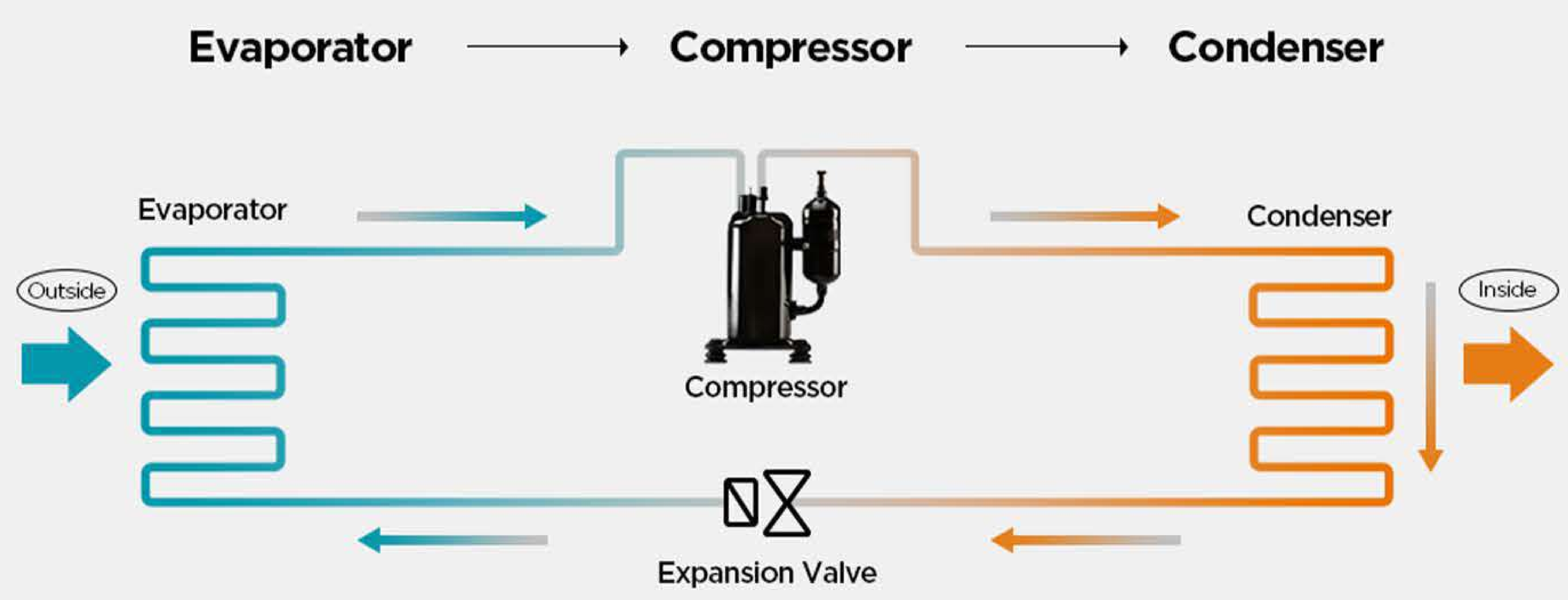
Now that we have established what heat pumps are and what they do, let's delve into the core components of heat pumps and the role each of them plays. We'll also explore the heating and cooling cycles of heat pumps to learn about how they provide comfortable indoor environments.

Heating Cycle

A heat pump's heating cycle begins in the compressor. The refrigerant in the compressor is compressed, which increases both the pressure and temperature. The high-pressure, high-temperature refrigerant then flows through an indoor coil and heat is transferred from the outdoor air into the refrigerant. The fan in the outdoor unit blows air over the coil to assist in the process of transferring the heat.

Next, the refrigerant travels through the refrigerant pipes and into the coil in the indoor unit, and the heat absorbed from outdoors is released to be circulated through the ductwork, fan coil unit (FCU), or underfloor heating system in the building.

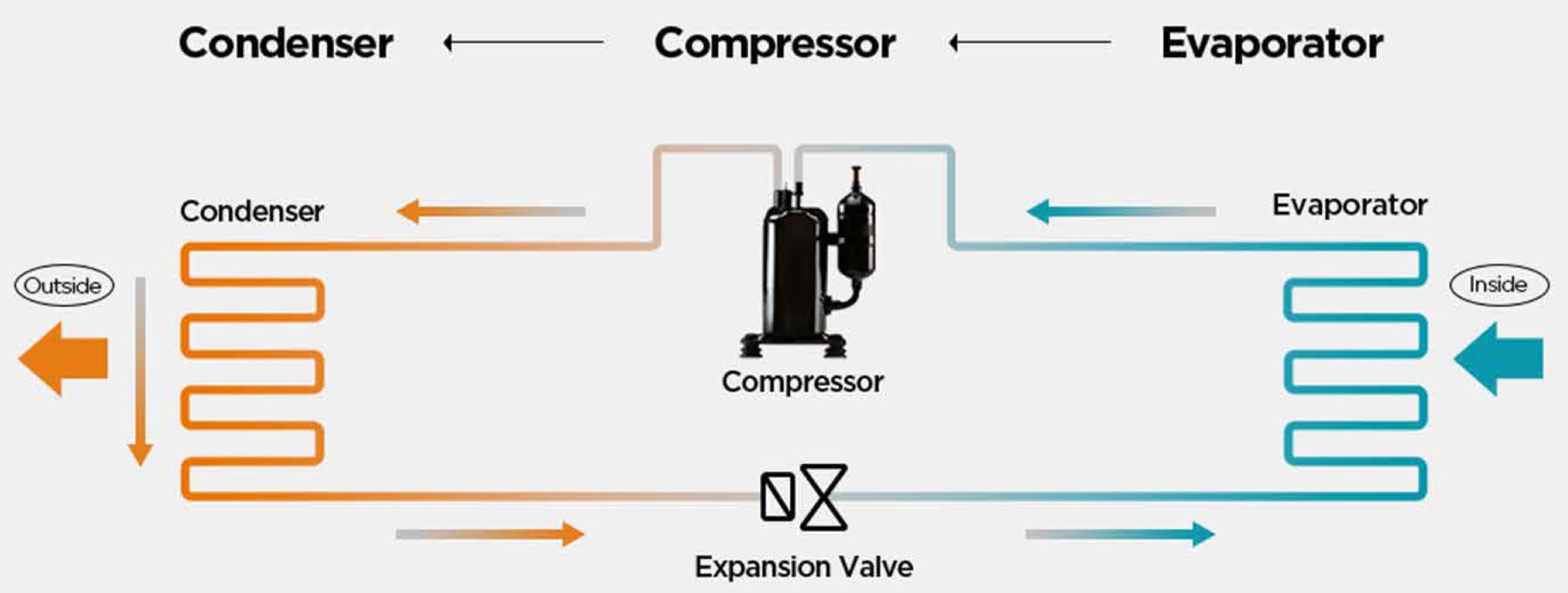
When this heat is released from the refrigerant, the refrigerant reverts back to a low-pressure, low-temperature vapor that moves back into the compressor to begin the cycle over again. In addition, heat pumps may also make use of auxiliary heating elements to supplement the heating process in extremely cold weather conditions.



Cooling Cycle

The cooling cycle of a heat pump essentially operates the same as the heating cycle but in reverse. The refrigerant is compressed in the compressor and moves through the outdoor unit coil to release heat into the air outside. Then, the refrigerant flows into the indoor unit coil and absorbs heat from the indoor air.

The fan in the indoor unit blows air over the coil to cool the air and distribute it inside the home. As the heat is disbursed from the refrigerant, the refrigerant becomes a low-pressure, low-temperature vapor that flows back into the compressor.



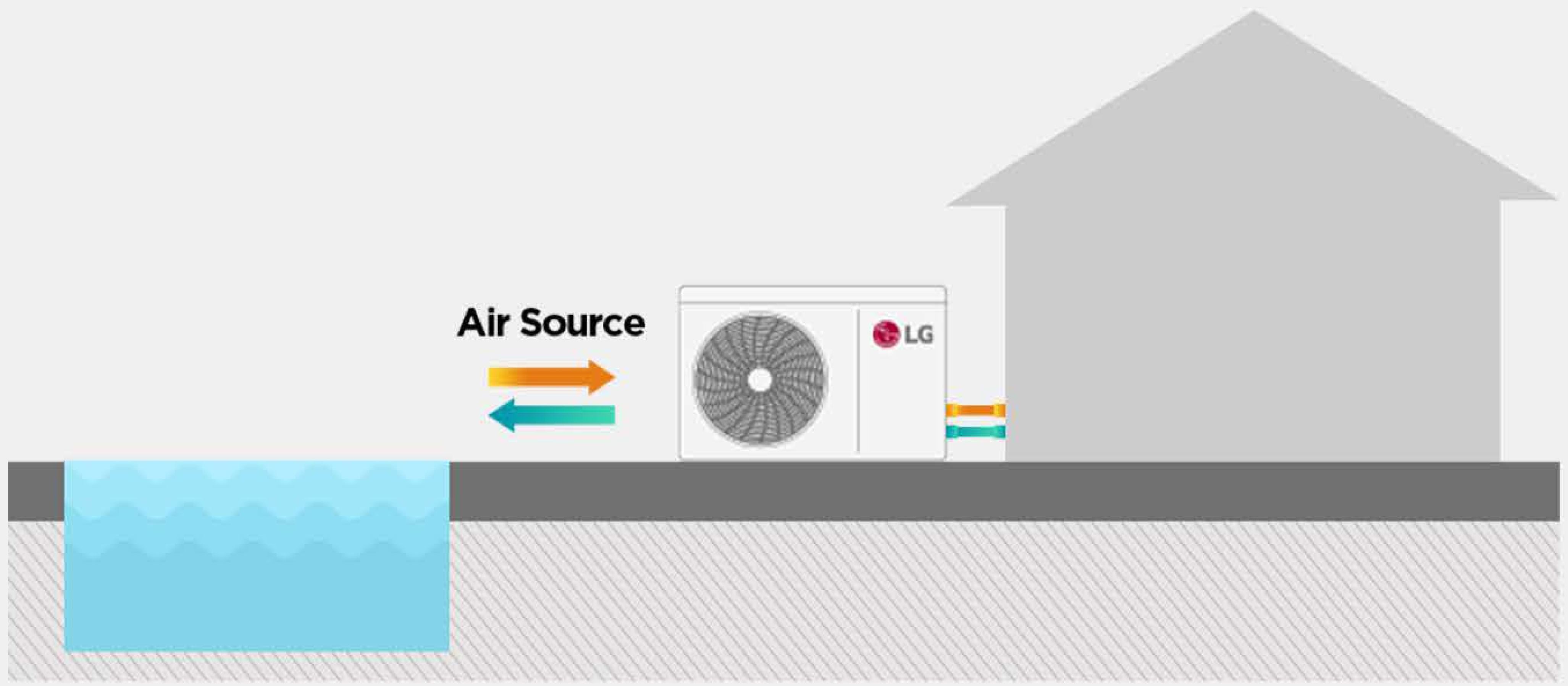
Types of Heat Pumps

As we covered above, heat pumps harness unused heat energy from natural sources such as the air, the ground, and water. The types of heat pumps can be classified according to the source they use to extract heat energy. Let's compare the pros and cons of the different types of heat pumps.

Air-Source

Air-source heat pumps are the most commonly used type of heat pump and can be categorized into air-to-water and air-to-air systems, depending on how they transfer energy. Unlike geothermal or water-source heat pumps, they do not require additional equipment to be installed.

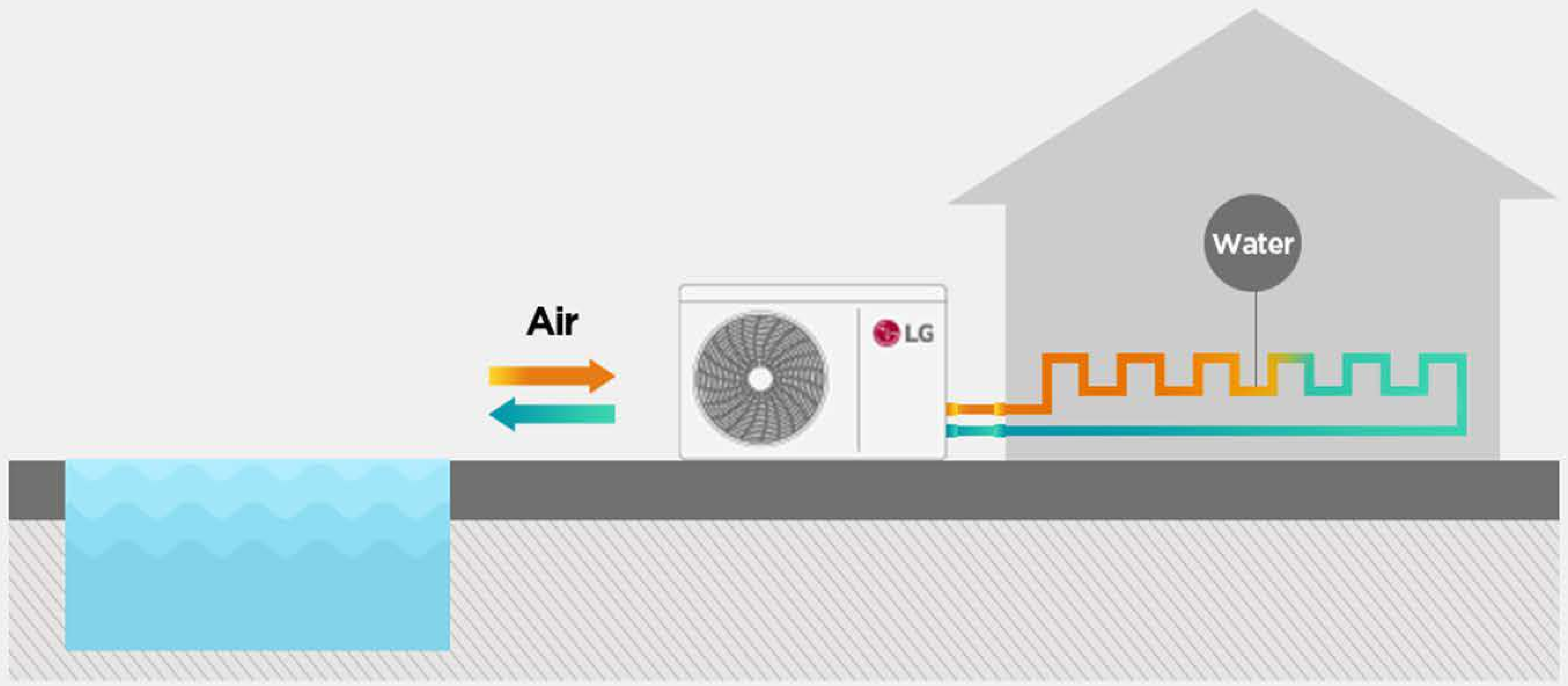
On the other hand, heating efficiency can decline in extremely cold temperatures. However, recent advancements in technology are allowing air-source heat pump systems to overcome this limitation.



Air-to-Water

As the name suggests, air-to-water heat pumps transfer heat from the outdoor environment into a water-based transfer system such as a radiator or underfloor heating. They provide efficient and effective heating even in relatively cold temperatures. However, a heat pump system may need to be supplemented with an additional heating system in extremely cold weather.

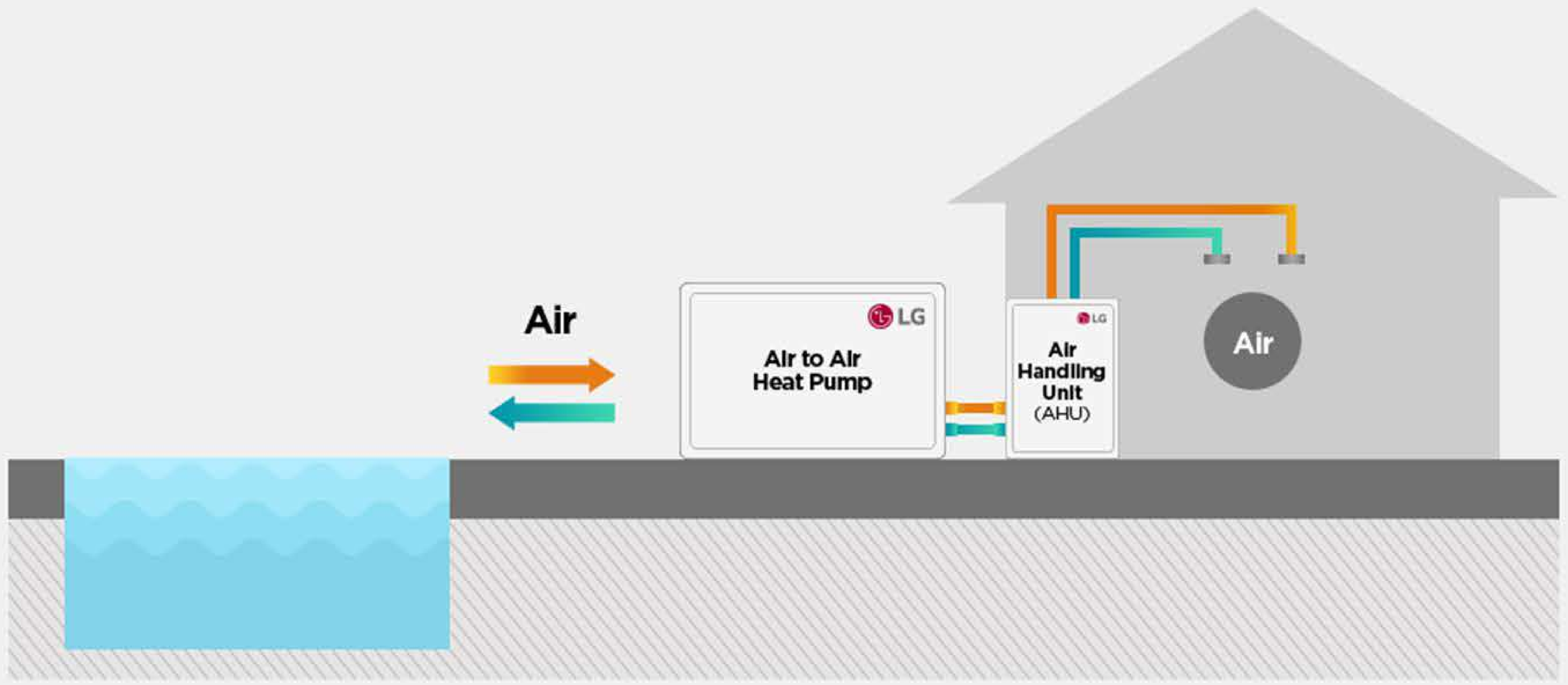
Although the upfront investment required may be high, long-term savings are realized through reduced energy consumption over the lifetime of the system. Aside from heating and cooling, air-to-water heat pumps also provide a source of hot water that can be stored and used later.



Air-to-Air

Fundamentally, air-to-air heat pumps function similarly to air-to-water heat pumps. The major difference between the two systems types is that air-to-air heat pumps deliver hot air directly into the home instead of through a water-based system. They are also able to provide both heating and cooling. Although air-to-air heat pumps are unable to provide hot water, they are a highly efficient solution for indoor climate control.

Heating performance and efficiency may be hindered in extremely cold environments and these systems may also require additional heating. Regular maintenance such as cleaning of filters is important for air-to-air heat pumps to ensure optimal performance and quality indoor air.



Geothermal

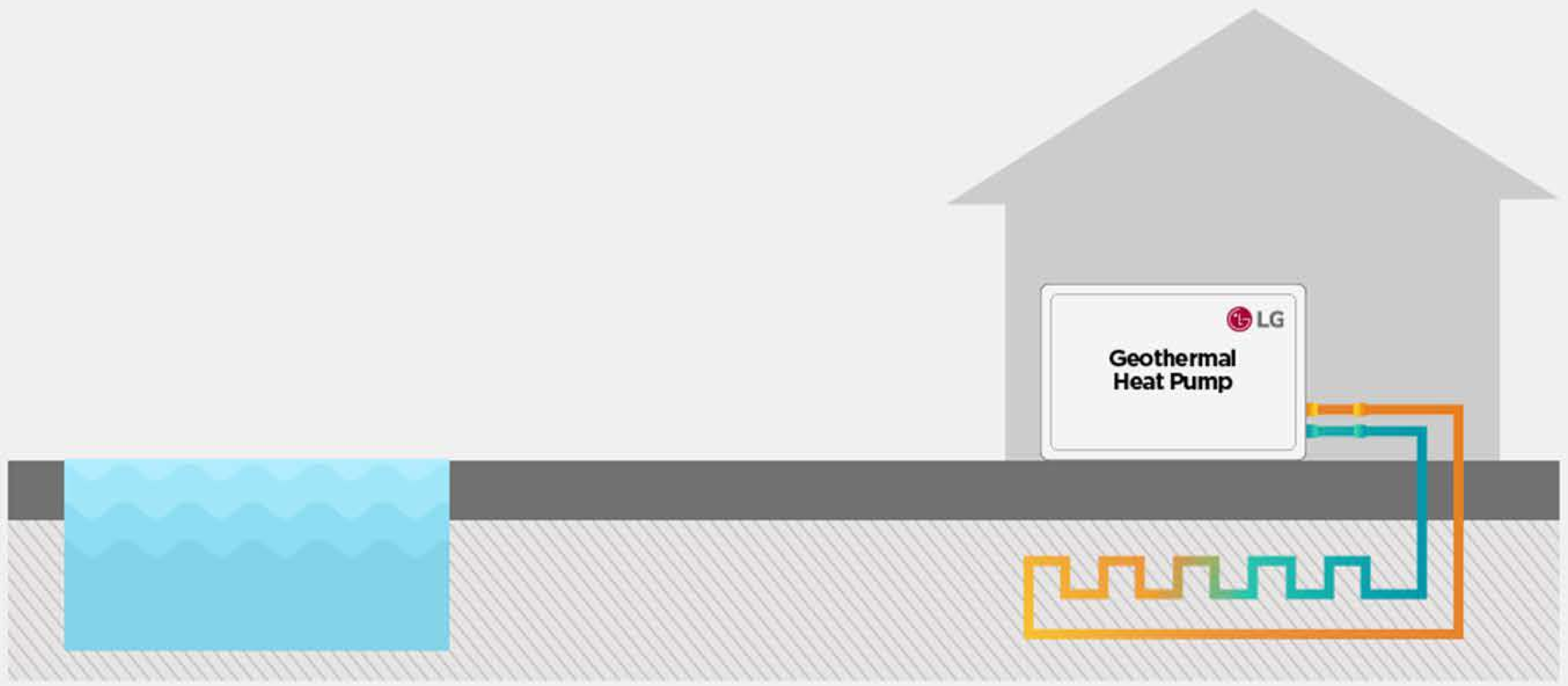
Geothermal heat pumps use refrigerant or water coolant to absorb or release heat from or into the ground via underground pipe systems known as ground loops. These systems can provide a more stable source of heating and cooling even in extreme temperatures due to the stable temperatures underground.

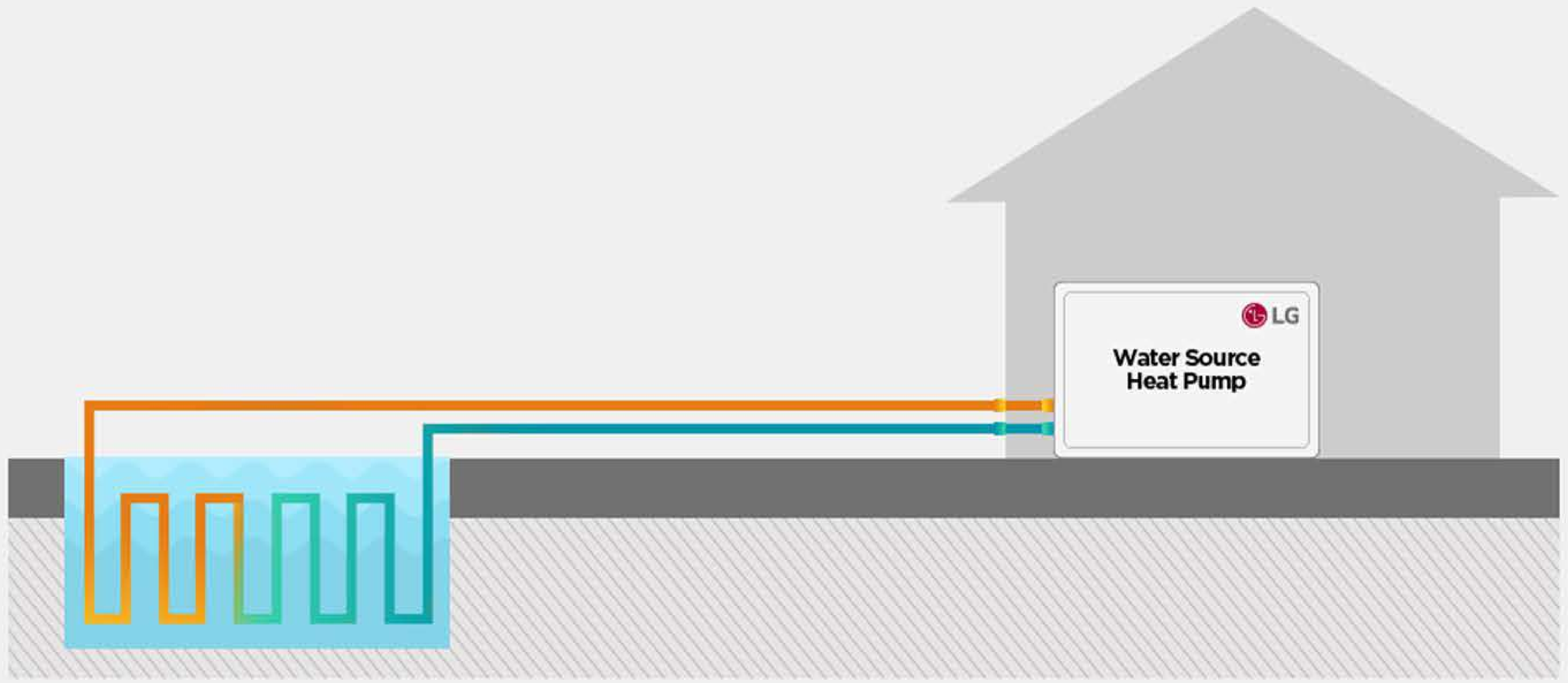
A downside to geothermal heat pumps is that they require a large amount of land to install the ground loop. The excavation and materials required for ground loop installation also come with a higher price tag than air-source solutions. In addition, the system has the potential to leak coolant into the ground and may require regular maintenance to ensure optimal performance and prevent issues such as freezing of the ground loop.

Water-Source

Water-source heat pumps transfer heat energy between a water source and the interior of a building. Similar to a geothermal heat pump, water-source heat pumps pump coolant through a system of pipes but the pipes run through a water source instead of the underground. More stable water temperatures allow these systems to deliver consistent heating and cooling even in harsh weather conditions.

A drawback to installing a water-source system is the cost and resources required to excavate and install the water loop. Furthermore, regular maintenance may be required to ensure optimal performance and prevent issues with the water loop such as corrosion or mineral buildup.





Benefits of a Heat Pump

Generally, heat pumps are known to be more efficient heating systems than conventional boilers. The efficiency of a product is indicated by labeling that differs by region. In the EU, energy efficiency classes are divided into 7 levels expressed as letters, with G being the worst and A being the best. Colors are also used to reinforce these levels, with red representing poor performance and green representing maximum efficiency. In addition, certain products, including heat pumps, can also be given A+, A++, and A+++, to indicate even further energy savings.

Aside from the high efficiency of heat pumps, they can also deliver more pleasant and balanced climate control, eliminating hot spots or cold spots. Evenly distributed heating and cooling create overall more comfortable indoor environments.

But energy efficiency and comfort aren't the only advantages heat pumps offer over other heating and cooling systems. Let's take a look at the advantages heat pumps provide over boilers or furnaces and traditional air conditioners.

Heat Pumps vs. Conventional Heating

Heat pumps provide heating, cooling, air filtration, and dehumidification in one unit, making them space-saving and cost-effective. Let's look at an example of cost savings based on averages in France.

An air-source heat pump can produce 4kWh of heat output for every 1kWh of electricity supplied. If we say, for example, that the average heating demand for a 4-person home (100m^2) using only electricity is about 16,000 kWh, the cost to heat a home for this demand with electricity at € 0.16 would be € 2,560.

With a heat demand of 16,000 kWh and a heat pump output of 4kWh per 1kWh of electricity, this shows us that we need about 4,000 kWh of electricity to heat the average home with a heat pump. At a cost of € 0.16 per unit of electricity for 4,000 kWh, the annual heating costs of a heat pump would be around € 640. Ultimately, this would lead to an annual savings of € 1,920.

Although cost savings is a major benefit of heat pumps, they also reduce energy waste and the risk of indoor carbon monoxide poisoning. Additionally, heat pumps operate quietly and require little maintenance compared to boilers or furnaces.

Heat Pumps vs. Conventional Air Conditioners

When compared to traditional air conditioning systems, heat pumps also provide some significant benefits. These versatile solutions offer both heating and cooling, which saves homeowners money on the installation of separate heating and cooling systems.

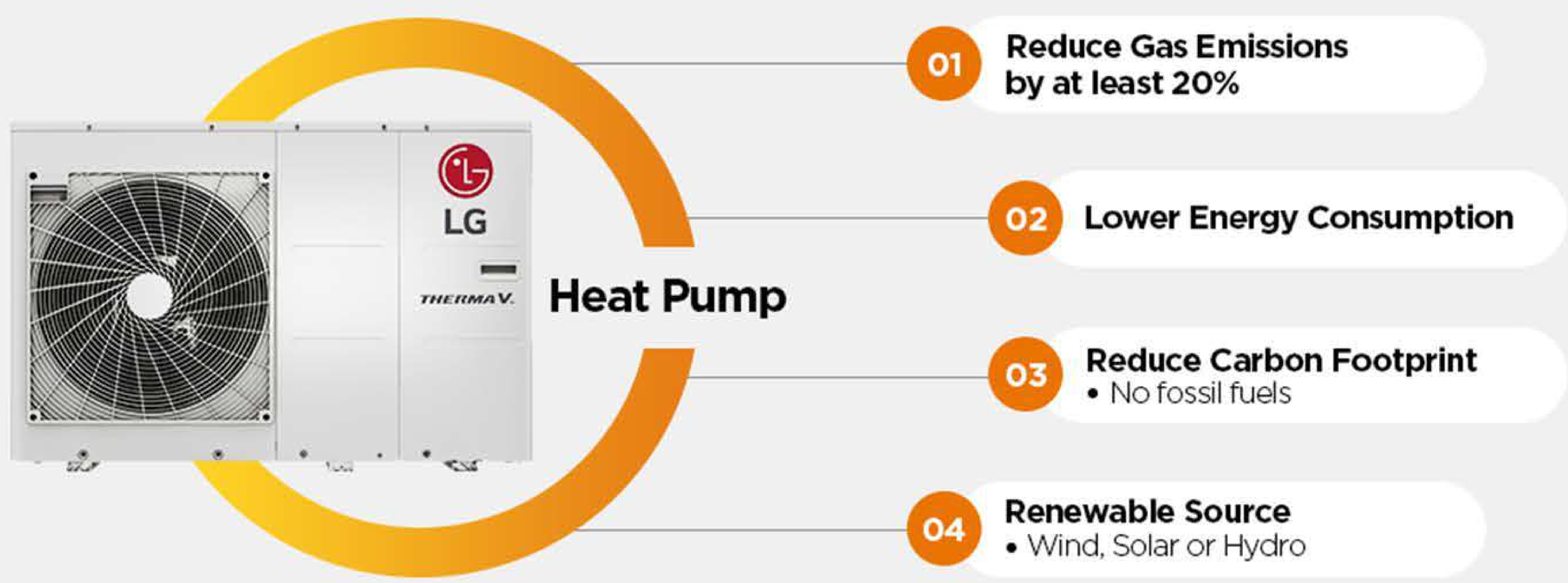
An all-in-one system also saves space in the home with less equipment required for comprehensive climate control. They function nearly identically in heating mode, providing a reliable source of heat during colder months. When it comes to operation, heat pumps run at reduced costs in moderate temperatures, resulting in significant cost savings for homeowners over time.

Heat pumps are also an effective solution for homeowners who are concerned about the environment.

Contributing to the Environment

In fact, compared to gas furnaces, heat pumps can reduce greenhouse gas emissions by at least 20%[3)]. They are certainly an effective alternative to furnaces and water heaters that use fossil fuels such as natural gas and heating oil, directly reducing carbon emissions. Heat pumps can also help to reduce carbon emissions indirectly if powered by renewable sources such as wind, solar, or hydro.

Heat pumps also provide important benefits that are better for the environment. First of all, they are more energy efficient than conventional heating solutions, resulting in lower energy consumption and a reduced carbon footprint.



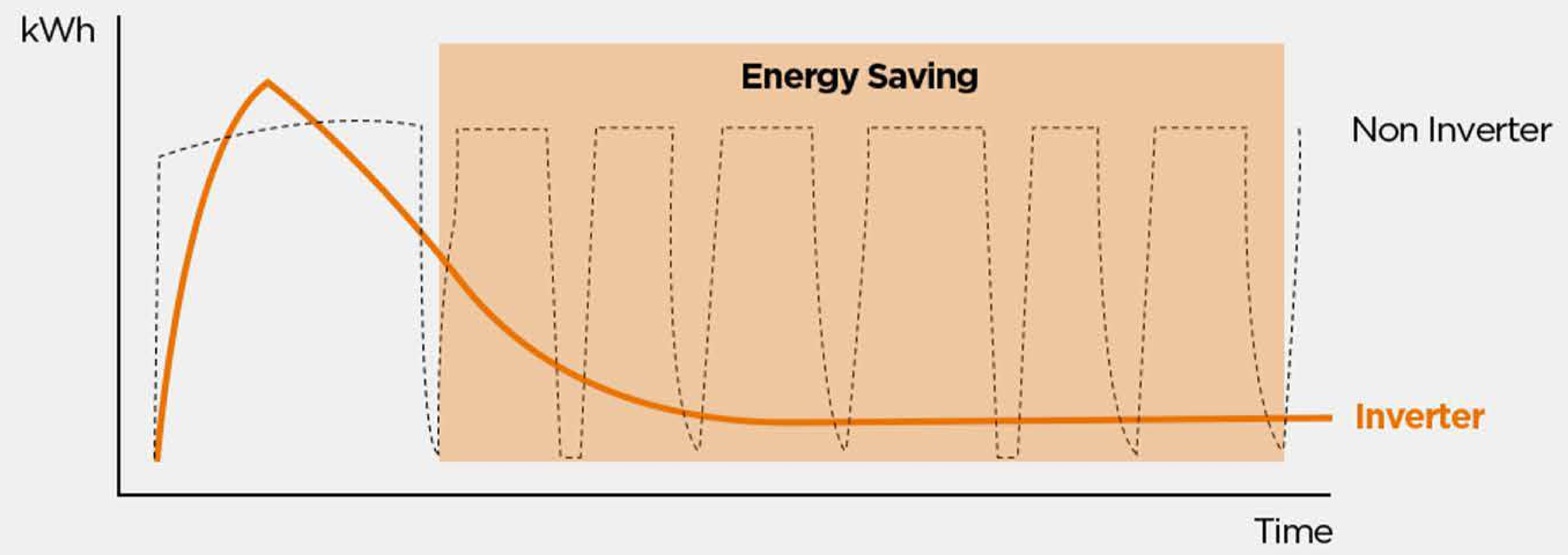
Things You Should Know About Heat Pumps

When considering to invest in a heat pump, there are some things to understand about these systems that will be beneficial to you.

Compressor and Energy Efficiency

Compressors are the key components in heat pumps and, ultimately, impact the efficiency of the overall system. This is why many heat pump systems use inverter compressor technology. Inverter compressors can be found in refrigerators, washing machines, and air conditioners. This technology allows the inverter compressor to achieve superior energy efficiency, cooling performance, and comfort compared to compressors with merely on/off capabilities.

Power Consumption Change



Refrigerant and Energy Efficiency

The type of refrigerant used in a heat pump will impact energy efficiency. Refrigerants such as R32 and R410A allow for more efficient heat pumps with more effective thermal energy transfer and lower impact on the environment.

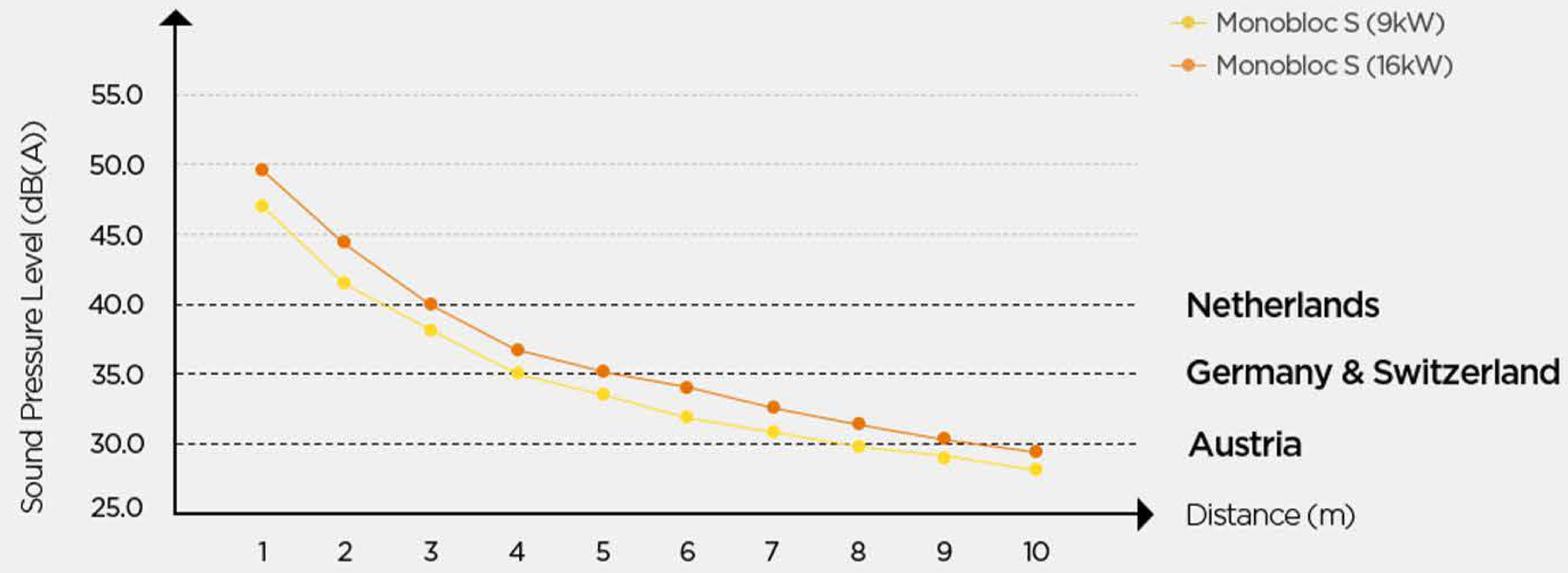
R32 is a sustainable and efficient refrigerant that has a low Global Warming Potential (GWP) and helps to lower energy costs. Additionally, R32 has a greater cooling capacity than other refrigerants, which makes it more effective at cooling your home or office. Overall, R32 is an excellent option for those looking to reduce their environmental impact, save money on energy bills, and enjoy efficient and effective cooling.

R410A is another highly efficient option that is also safer for the environment and the home. This refrigerant does not deplete the ozone layer. Like R32, R410A has a good cooling capacity and is more effective in providing comfortable indoor environments and lower energy costs than many other refrigerants. Additionally, R410A is non-flammable and non-toxic option that is safer to use in your house.

Noise

Once of the most notable issues with heat pumps is noise emissions. The latest heat pump technology has made low-noise solutions possible. For example, the LG Monobloc (9kW) system is rated as 35dB at 4 meters, which is compliant with German and Swiss standards.

Sound pressure level based on the distance from the Outdoor Unit



Smart Management System Connectivity

An HVAC system is only as good as its management system. Heat pumps with Wi-Fi connectivity allow installers to provide faster and more convenient service with constant system monitoring through remote cloud-based access. Technicians can also detect system issues before they occur and provide more accurate diagnoses. This remote diagnosis reduces the number of on-site visits required for service and also reduces the time it takes to service or repair the system. Of course, the end user can also access the system remotely and use voice recognition to set the temperature and regulate system usage anytime, anywhere.

Defrost

Frost buildup on the heat exchanger of a heat pump outdoor unit can significantly decrease system performance. Frost forms when the outdoor temperature is low and humidity is high. Some heat pumps offer automatic defrost functions that can deal with this issue and put your mind at ease. During the defrost process, the heat pump system is paused for 5-7 minutes as the frost melts. Once the frost is melted, vapor can then be properly generated in the outdoor unit.

Insulation

Whether or not you're using a heat pump, a properly insulated home will increase the efficiency of your HVAC system. However, insulation is essential to the efficiency and comfort provided by a heat pump. Effective insulation prevents hot and cold air from passing through the walls of your home. It captures the heat within the building by keeping heat from moving in its natural path from warmer to cooler areas outside or in adjacent spaces such as attics, basements, and garages.

Without proper insulation, heat can escape from the home during cold weather, making the heat pump work harder to maintain the desired temperature. This results in increased energy consumption and higher energy bills. Similarly, in hot weather, heat can enter the home, making the heat pump work harder to cool the indoor space, again resulting in increased energy consumption and higher energy bills.

In summary, proper insulation is critical for homes with heat pumps because it helps to maintain the desired temperature inside the home, reduces energy consumption, and saves on energy bills. When heat is lost from your home in the winter, a heat pump system will have to work much harder to replace that lost energy and increase energy costs.

Conclusion

In conclusion, this whitepaper sheds light on the importance of heat pumps as effective heating solutions that conserve energy, reduce heating costs, and minimize the impact of HVAC systems on the environment. The potential of heat pumps has become even more relevant with the growing importance of reducing greenhouse gas emissions and mitigating the impact of climate change. The paper also discusses the challenges heat pumps face in the market, such as high upfront costs and technical limitations. However, the latest technological advancements and support from government policies are facilitating the widespread adoption of heat pump technology. Overall, this whitepaper provides a comprehensive overview of heat pump technology, how it works, and the advantages it provides over conventional heating solutions.

* The products in this white paper may vary by country or region. For further information, please contact your local LG representative.

Air to Water

Therma V Split

Therma V Hydrosplit

Therma V Monobloc S

Water Heater

Air-Cooled Scroll Heat Pump

Air-Cooled Screw Heat Pump

Air to Air

Multi V (VRF)

Single Split

Multi Split

Gas Heat Pump (GHP)

Geothermal

Screw Geothermal Heat Pump

Scroll Geothermal Heat Pump

Water to Water

Centrifugal Heat Pump

Absorption Heat Pump

Water-Cooled Screw Heat Pump

Product Line-Up

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