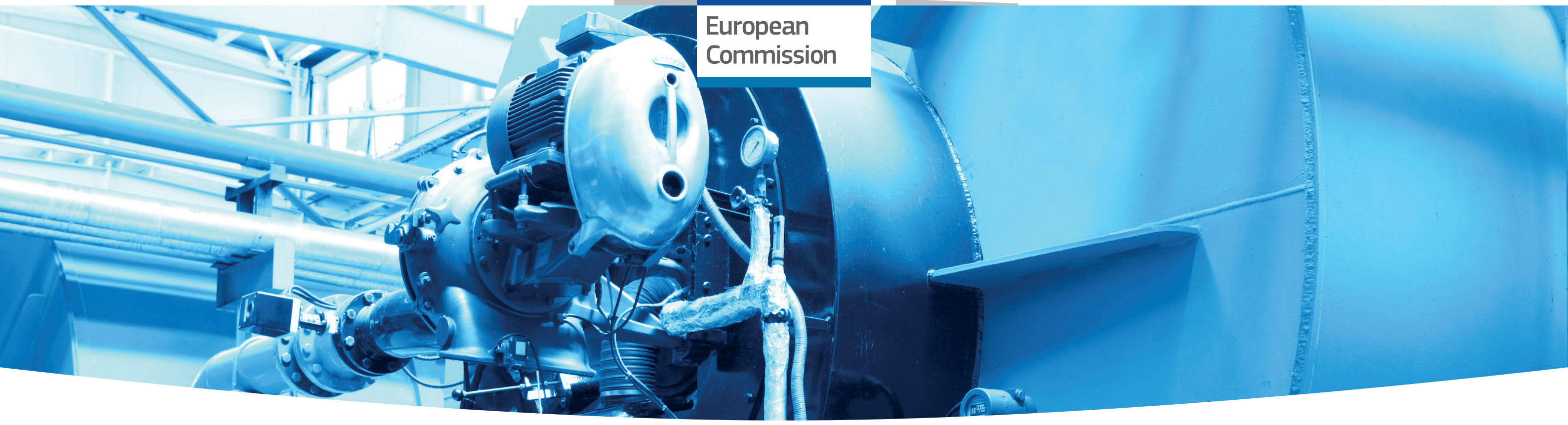
European Commission



Heat Pumps

In brief

Close to 50 % of the total final energy demand in Europe is accounted for by heating and cooling. As most of this demand is met by fossil fuels there is significant scope to increase the share of renewables in the heating and cooling sector.

Heat pumps have been identified as a technology that can contribute to the European Commission's renewable energy and climate targets. Synergies between heat pump technology on the demand side and decarbonisation on the supply side can be exploited to make a significant contribution to reducing CO_2 emissions.

A versatile technology, heat pumps can be used to provide space heating and cooling and hot water, all from one integrated unit. Furthermore, heat pumps can be used in hybrid renewable / conventional systems, can store surplus electricity in the form of thermal energy and can integrate and optimise the performance of different energy resources in the electricity grid.

> **"Renewable heating and cooling are vital to decarbonisation. A shift in energy consumption towards low-carbon and locally produced energy sources (including heat pumps and storage heaters) and renewable energy (e.g. solar heating, geothermal, biogas, biomass), including through district heating systems, is needed."**
>
> Energy Roadmap 2050

The technology

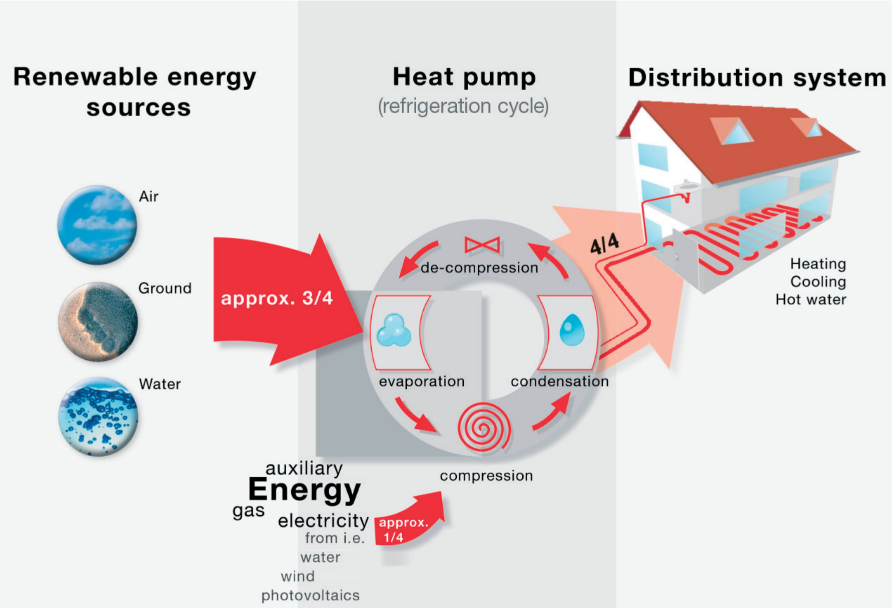
Heat pumps are based on a mature technology that involves the transfer of thermal energy from a heat source to a heat sink using a compression cycle that takes advantage of temperature gradients. Pumps can be driven by electricity or by thermal energy, the main difference being that electrical heat pumps use a mechanical compressor, while thermally activated heat pumps achieve compression by thermal means.

One of the advantages of using thermally activated heat pumps is their high output temperature and simple integration with existing heating systems and infrastructure. Moreover, electric heat pumps can operate on the grid in response to electricity prices and contribute to optimal load management.

Heat pump systems operate using different working fluids, each with their own advantages and disadvantages, and the choice of a working fluid will depend on the specific application of the pump. Fluorinated gases (F-gases), which have a high global warming potential (GWP), are still widely used in air conditioning and heat pump equipment. Furthermore, CO_2 and ammonia are currently the two main refrigerants used for high-capacity heat pumps. In absorption systems, which use liquids or salt to absorb vapour, the most common combinations of working fluid and absorbent are water/lithium bromide and ammonia/water.

Heat pump performances and efficiencies have increased considerably over the past 30 years, largely thanks to better system integration and new technologies and components such as compressors, pumps, fans, heat exchangers, expansion valves and inverters.

Factors that influence heat pump efficiency include the water temperature adjacent to the condenser, humidity and ambient air



Source: EHPA'

temperature, set point temperature, the hot water draw profile, auxiliary energy consumption and the operating mode. Heat pump units that operate at a high level of efficiency can have low CO_2 emissions. In particular, ground-source heat pumps can reduce energy consumption and corresponding emissions by 63 to 72 %[1] when compared to electric resistance heating combined with standard air conditioning equipment. However, as electrically-driven heat pumps are currently the most common, the level of CO_2 emissions will also depend on the share of electricity from renewable sources used in operating the pumps.

The industry

The EU market[3] is dominated by air/air and air/water units, followed by geothermal units that are mainly used for heating. Reversible air/air units are more common in countries with warm climates, while colder climates demand a more stable source temperature, resulting in a larger share of ground-coupled units. Overall, the air-source segment, including reversible heat pumps and exhaust air heat pumps, remains the largest. However, in recent years there has been an increase in the share of sanitary hot water (SHW), which currently represents 9 % of the total market.

New growth opportunities for heat pumps exist in the renovation sector, and their potential remains stable in both the commercial and industrial sectors. The SHW segment for both residential and commercial applications has shown the highest growth in recent years. In terms of energy source, there is a pronounced trend towards aero-thermal energy in most markets and this segment accounts for most of the market growth. These solutions are proving to be ideal in combination with small gas boilers in hybrid applications, and a drop in gas prices has brought the operating costs of gas boilers closer to those of heat pumps.

Fact file

- Thermally-driven heat pumps can be subdivided into absorption pumps, which use high-temperature heat; and adsorption pumps, which incorporate low-temperature energy and convert it to a higher temperature.
- Electrically-driven heat pumps have higher efficiencies compared to absorption heat pumps and typically the investment costs per heat output are lower for absorption heat pumps.
- Heat pumps using CO_2 can be used for applications with temperatures up to 90°C whereas new ammonia systems are capable of reaching temperatures up to 100°C.
- The most common heat pumps in the residential sector are air/air units and split-air conditioners for air conditioning.
- Air-source heat pumps (ASHPs) can provide sanitary hot water and space heating and cooling, while avoiding the need for expensive ground or water loops.
- Ground-source heat pumps, which use underground heat exchangers, have higher efficiencies in cold weather than ASHPs.
- The EU heat pump market[2] exceeded EUR 6 174 million in 2011. France, Italy and Sweden are the three countries with the highest volume of sales, with Belgium, the Netherlands, Poland and the UK expected to make a significant contribution to market growth in the future (EHPA, 2012).
- Heat pump sales to households in 2005 - 2010 showed a considerable market penetration in the Scandinavian countries, followed by Austria, Estonia, Italy and Switzerland. Other European countries have lower market penetration values, indicating potential for further growth.

1 US Environmental Protection Agency
2 Based on EU-21 values (IEA, 2013)
3 Based on EU-21 values (IEA, 2013).

The European heat pump market has undergone major changes recently, with a clear trend towards the creation of medium- and large-sized enterprises capable of offering global heating and cooling solutions. It should also be noted that traditional air conditioning manufacturers, including Japanese and Korean suppliers, have expanded into the combined heat and cooling sector.

Barriers

Apart from the price ratio of electricity to conventional fossil fuels, major barriers preventing the widespread deployment of heat pumps include insufficient recognition of the benefits of the technology and the high investment costs involved, especially for ground-source installations. Stakeholders and consumers need to have a better understanding of how the technology can effectively contribute to GHG mitigation in the heating and cooling sector.

The sector has identified a number of factors that are considered essential to achieve large-scale deployment of heat pumps. These include international heat pump efficiency standards and a labelling system. Other key factors include government support and specific regulations encouraging the use of heat pumps. The provision of financial incentives and subsidies would also promote heat pumps as a technology capable of helping achieve the EU's 2020 and 2050 renewable energy and climate targets.

The large scale deployment of heat pump technology is also affected by factors that are common to other emerging technologies, such as uncertainties in the markets and the long-term nature of investments in the energy sector. On the whole, in order for heat pump technology to achieve its full potential, investments in infrastructure are still needed, along with supportive business initiatives and an increased social awareness of environmental issues.

Ongoing research

The main areas in which an ongoing R&D effort is needed include the optimisation of operational plans and control systems, and the design of load management strategies and installing protocols.

Optimal integration of heat pumps with alternative heating and cooling technologies (in particular, conventional boilers and solar technology) constitutes one of the main challenges in order to achieve large-scale deployment in the near future. Integrated solutions will be key to increasing the use of renewable and low-carbon technology in building renovation applications. With a low level of investment and minimal installation costs, small heat pumps could supply most of the annual heating demand currently being supported by boilers at low ambient temperatures, or they could be used to cover peaks in demand.

The performance of heat pumps in cold and/or warm climates is another area requiring additional R&D. The efficiency and heating capacity of air-source heat pumps decreases considerable in cold climates. Meanwhile, in warm environments, the use of geothermal energy could be encouraged by promoting reversible heat pumps as an effective means of both heating and cooling. In general, the efficiency of cooling needs to be increased in reversible systems.

Needs

Even though heat pump technology is mature and well established, there are still some challenges to be overcome in order to enhance overall performance and operation. The use of alternative materials will help to reduce the cost of equipment and components.

Additionally, the selection of refrigerants capable of maximising performance while minimising GWP also constitutes a challenging area that will benefit from additional R&D activities. It should be noted that no single refrigerant exists that can be used with the same economic and environmental efficiency across all application requirements. Considerable effort has been made to analyse the efficient use of natural refrigerants (CO_2, ammonia and hydrocarbons) and to develop new synthetic refrigerants. Both development pathways have their disadvantages: the use of natural refrigerants comes at the cost of reduced efficiency, flammability or toxicity, while new synthetic refrigerants are not yet completely understood with regard to safety and their impact on the environment.

As heat pumps are often oversized, it will also be necessary to optimize the design of the units in order to achieve optimal performance and reduce costs. Heat pump technology will also benefit from improvements and research in cross-cutting technology, including cost reduction in drilling processes for geothermal units and reduced energy loss in pipe technology.

For further information:

The European Heat Pump Association
http://www.ehpa.org/

The European Technology Platform on Renewable Heating and Cooling
http://www.rhc-platform.org/