PAPER

Heat pumps: a key technology for the EU energy transition to net zero emissions

This document outlines how heat pumps work. It formed part of the European Heat Pump Association's (EHPA) response to the public consultation opened by the European Chemicals Agency (ECHA) on the proposal to restrict Per- and polyfluoroalkyl substances (PFAS) under the EU chemicals regulation REACH.

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In January 2023, the national authorities of the Netherlands, Germany, Sweden, Denmark and Norway submitted their Restriction Proposal to the European Chemicals Agency (ECHA). The proposal aims to restrict the manufacturing, the placing on the market (including import) and the use of certain substances in Europe. It covers over 10,000 substances, including Fluorinated gases (F-gases) and fluoropolymers that are used in heat pump equipment.

The European Heat Pump Association (EHPA) is participating in ECHA's public consultation on the proposal by providing an overview of how heat pump technology works, and its importance for society, as well as for the EU's energy, climate and energy security targets.

1. The benefits of heat pumps: protagonists of the EU energy transition

The heating and cooling sector is responsible for 51% of final energy demand in Europe and for 27% of its CO_2 emissions. Decarbonising society is impossible without decarbonising heating and cooling.

Heat pumps are fully recognised as the key technology to make heating more secure and sustainable, as shown by their vastly increased role in EU energy and climate policy. In Europe, all the heat pumps connected by the end of 2022 avoided over 54 million tonnes of CO_2 – about the annual emissions of Greece.

The REPowerEU plan, presented in May 2022 in response to Russia's invasion of Ukraine, sets targets for water-based heat pumps which, when applied to all types, will come to a total of 20 million installed heat pumps by 2027 and an additional 60 million installed by 2030 compared to 2021 stock.

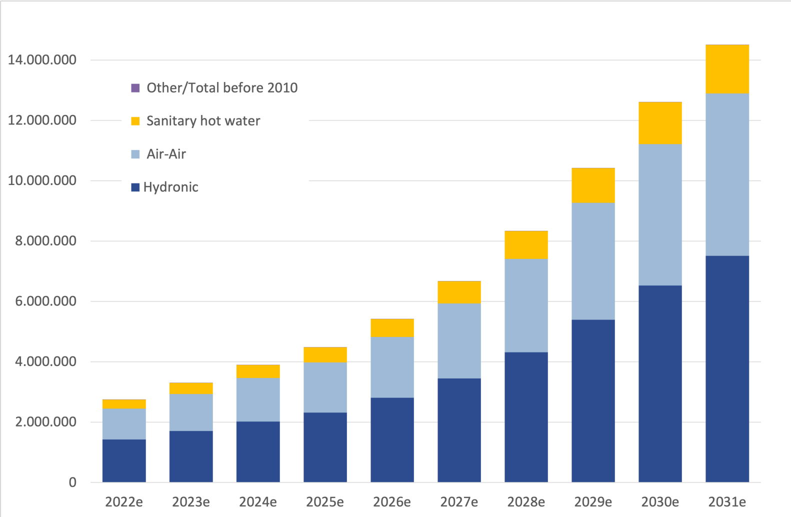
A fast heat pump roll-out to achieve the 2030 target would reduce gas demand in buildings by 40% by 2030 compared to 2022 and decrease the EU's energy import bill by €60 billion over the same period. What's more, replacing about a third of EU's 86 million residential fossil fuel boilers with heat pumps could cut those households' final energy consumption by 36% and their CO_2 emissions by 28%.[1]

Heat pumps are beneficial to the European economy. Increasing their uptake, in line with the REPowerEU plan, will create almost 3 million net additional jobs by 2030.

Alongside the economic and environmental benefits of heat pumps are the health benefits they provide. This is because they do not produce harmful emissions in the way burning fossil fuels and biomass does. If the REPowerEU ambitions are met, nitrous oxide (NOx) emissions from household heating would also fall by almost 40% by 2030 compared to 2022.

To capitalise on the climate and socio-economic benefits of the widespread deployment of heat pumps, it is essential that they can be scaled up fast and the components and materials needed are available to manufacture them.

[1] Residential heating: heat pumps would knock down energy consumption and emissions, European Commission (2023)



Title: The EU ambition in numbers

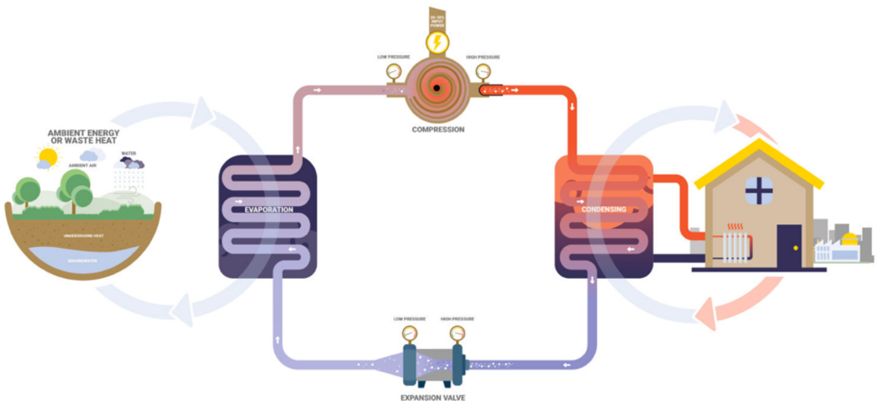
Source: European Heat Pump Association

2. How does a heat pump work? The basis of the refrigeration cycle

A heat pump is a device that can provide heating, cooling and hot water for residential, commercial and industrial use. Despite the name, all heat pumps can provide both heating and cooling. They work well in nearly all types of climates. Heat pumps take energy from the air, ground and water and turn it into heat or cold (water or air). This works due to what is known as the refrigerant cycle.

These are the components involved:

- Heat exchanger (e.g. evaporator, condenser, desuperheaters, subcoolers)
- Case, pipes, cables
- Fan
- Pump
- Heat transfer fluid (refrigerant)
- Controller
- Valves
- Compressor
- Vessels
- Lubricating oil



Title: The refrigerants cycle

Source: European Heat Pump Association / Doug Dawson

All components contribute to the refrigeration cycle, with the heat transfer fluid (refrigerant) being piped between the condenser, valve, evaporator and compressor. This thermodynamic process enables the working fluid to absorb the surrounding heat at a low temperature and reject the heat into the heating system or the industrial process at a higher temperature. This is accomplished by handling the pressure of the working refrigerant through a cycle of compression and expansion. Finally, the reversing valve makes sure that the flow of the system's refrigerant is reversible.

3. Diversity of heat pump applications, technologies and aspects to be considered

Heat pumps, by design, are far more efficient than conventional heating technologies.[2] Heat pumps can provide carbon neutral heating, cooling and hot water for a wide range of residential and commercial applications, including hospitals, offices, commercial spaces or in industrial settings.

The applications of heat pumps are diverse and include:

- Single homes
- Multi-family homes
- Multi apartments buildings
- Commercial areas
- Offices
- Public buildings, including social housing
- Hospitals
- Schools
- Hotels
- Large space areas
- Industrial processes
- District heating and cooling

For further information, examples and illustrations, please consult the report *"Heat Pumps Integrating technologies to decarbonise heating and cooling"* in the annexes.

Furthermore, there is a range of technological variations in a heat pump system, offering diversity in usage, thermal sources, energy sources, sinks, capacities, design, compressor types, capacity control and refrigerants.

Diversity in usages:

- Space heating: human comfort, agriculture, logistics
- Space cooling: human comfort, agriculture, data centers
- Water heating: domestic hot water, swimming pools
- Combi (space and water heating)
- Multi functions (space/water heating + ventilation or space/water heating + air cooling) o district heating/cooling
- Industrial processes

Diversity in main thermal source:

- Air
- Water
- Ground
- Sewage/grey water
- Waste heat

Diversity in auxiliary energy source:

- Electricity
- Gas

[2] The Future of Heat Pumps, International Energy Agency (2022)

- Hybrid solutions

Diversity in sinks:
- Air
- Water
- Brine

Diversity in capacities:
- Small (residential) 2 to 20 kW
- Light commercial 20 to 200 kW
- Heavy commercial, industrial > 200 kW

Diversity in systems design
- Split systems
- Multi-split systems
- Monobloc (outdoor, indoor)
- Integrated in other systems

Diversity in compressor types:
- Rotary
- Scroll
- Piston
- Screw
- Centrifugal

Diversity in capacity control:
- Fixed speed
- Staged
- Variable speed

Diversity in refrigerants used:
- HFCs
- HFOs
- Non-fluorinated refrigerants (HC, C02, NH3) and blends thereof

4. Focus on refrigerants: HFCs and HFOs

Heat pumps rely on refrigerants to operate. These refrigerants can be classified as either fluorinated or non-fluorinated alternative refrigerants. Fluorinated refrigerants (F-gases) are gases that are mainly used in the refrigeration, heat pump and air conditioning sectors.

In the context of heat pumps, it's worth noting that some systems will continue to rely on fluorinated gases, such as Hydrofluorocarbons (HFCs) and Hydrofluroolefins (HFOs). This is primarily because, for specific applications, they currently represent the most practical and safe choice. Transitioning to non-fluorinated refrigerants remains a significant journey, considering that it will take considerably more time than initially proposed in the restriction proposal. Achieving alignment across the value chain, adhering to updated building codes, ensuring stringent compliance with safety regulations and implementing all necessary adaptations are complex tasks that will extend the timeline substantially. It's worth noting that HFOs have a similar GWP value to many non-fluorinated alternatives.[3]

As for those F-Gases falling under the PFAS definition because they have been found decomposing into Trifluoroacetic acid (TFA), **the latest scientific findings from the UNEP Environmental Effects Assessment Panel (EEAP)** [4]**state that no harm is anticipated from those TFA sources,** even when considering their increased use in the future as a replacement for Ozone Depleting Substances (ODS).

[3] Selecting and Using GWP values for Refrigerants, EFCTC (2021)
[4] Environmental Effects of Stratospheric Ozone Depletion, UV Radiation, and Interactions with Climate Change, UNEP (2022)

As a general principle, the most effective method for preventing emissions from refrigerants is to subject them to a reclamation process, which fulfils the circular economy principles.

5. Essentiality of Fluoropolymers in HVACR Systems

Fluoropolymers included by the PFAS under REACH approach can also be utilised in the components mentioned above, given their numerous properties such as heat resistance, low friction and high adaptability.

Given the mechanical conditions and harsh internal environments of Heating, ventilation, air conditioning and refrigeration (HVACR) equipment and systems, materials must be able to withstand these conditions awhile retain sufficient mechanical and physical integrity throughout their prolonged period of use. Temperatures can range from -50 to 175°C, and pressures can range from near a vacuum up to 45 bar in R-410A systems, or up to 120 bar in CO_2 systems.

Fluoropolymers provide an unmatched combination of key high-performance properties that deliver the required reliability and functionality to components in HVACR equipment. While alternative materials may have one or more of the required properties, they often fall short of meeting all the material requirements for these components. In contrast, fluoropolymers simultaneously fulfil several essential properties crucial to the HVACR sector.

It's noteworthy that fluoropolymers meeting the criteria for being considered "polymers of low concern"[5] typically do not cause relevant emissions to the environment when used as intended.

So as not to offset the advantages brought by a fast heat pump roll-out, it is crucial to implement **a time-unlimited derogation for refrigerants in HVACR equipment. The reduced adoption of heat pumps would result in a greater reliance on gas boilers, forcing consumers to adhere to environmentally harmful fossil fuel solutions.**

Conclusion:

Many aspects need to be considered when opting for the most suitable heat-pump solution for any given use case. Among the diversity of technological solutions in play, refrigerants are just one piece of the puzzle. **A "silo" approach on refrigerants, specific components or substances could lower EU's climate ambition level and lead to unintended environmental, social, economic and political consequences for the EU's citizens and businesses.**

The joint existing commitment by industry and policymakers to speed up the deployment of heat pumps by 2030 and beyond requires a flexible regulatory framework regarding the choice of refrigerants and other components. In contrast, **any new measure that would limit the availability and/or the choice of refrigerants and components (bans, stricter phase-down) to be used by heat pumps would slow-down the speed at which heat pumps need to be installed and put at risk the EU carbon-neutral net zero objectives.**

Allowing the use of a full range of refrigerants and other components will contribute to the implementation of an unprecedented level of EU emissions reduction ambition and the heat-pump growth as it is expected in the coming years, allowing the EU to **reduce Europe's dependency on fossil fuels in the heating sector**.

Therefore EHPA is requesting a time-unlimited derogation for F-gases use in HVACR equipment given the arguments above.

[5] Data Analysis of The Identification of Correlations Between Polymer Characteristics and Potential For Health Or Ecotoxicological Concern, OECD (2009)

The documents annexed to this file include the papers:

- Heat Pumps: integrating technologies to decarbonise heating and cooling, European Copper Institute (2018)
- The Heat Pump Wave: Opportunities and Challenges, JRC European Commission (2023)
- Heat Pumps in Europe – Key Facts and Figures, European Heat Pump Association
- Explanatory note on the need for the use of a diverse range or refrigerants in the heat pump sector, European Heat Pump Association
- The Future of Heat Pumps, International Energy Agency (2022)

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The **European Heat Pump Association** (EHPA) represents the European heat pump sector.

EHPA works to shape EU policy that allows heat pumps to become the number one heating and cooling choice by 2030 and a key part of a future decarbonised Europe.

EHPA advocates and communicates to policy-makers and to our members. EHPA organises high level events and is involved in multiple projects.

EHPA coordinates the Heat Pump Keymark – a European certification scheme.

More: ehpa.org