How big a role for heat pumps in decarbonising Europe’s heat?

Heat pumps will of course contribute to the decarbonisation of Europe’s heat market — but how major a role might this be? Thomas Nowak of the European Heat Pump Association is understandably bullish about the versatility and efficacy of the technology.

Decarbonising heat will be more difficult than creating a low carbon electricity sector — it is even possible! This is an interesting question. Is it really more difficult to decarbonise heat than to decarbonise electricity? Looking at available data, energy demand for heating in Europe amounts to around 6,360 TWh and for electricity to around 3,240 TWh. While the share of renewables in electricity (29.6%) exceeds that in heating (19.1%), in absolute terms more renewable energy is used in heating than in electricity generation (1,154 TWh versus 939 TWh), according to data for 2016 from Eurostat.

It is easier to decarbonise electricity. Probably yes, at least for the time being, since green electricity generation requires fewer emissions with a larger impact. While introducing renewable energy into the heating sector is the consequence of many individual decisions with a smaller impact.

Heat decarbonisation is probably going to require the use of several different technologies — how important will heat pumps be? Proven and market-ready solutions exist for all climate zones and application areas, and include heat pumps, biomass boilers, solar thermal collectors, geothermal power and thermal plants, cogeneration units using green fuels and hybrid solutions combining several of the items mentioned. However, their share in the market is not yet significant, so political impetus is vital in order to shift the need for affordable energy to a new mindset based on a Paris treaty compliance check.

Heat pumps will have to play a bigger role in deep decarbonising heating and cooling due to their specific benefits of meeting individual heat demand throughout the year, location and time of availability between supply and demand. Some facts:

- Heat pump technology can use renewable or excess energy at a lower temperature level to provide useful higher temperature heat.
- Heat pumps always provide heating and cooling at the same time. If both services are needed, they reach the highest possible energy efficiency.
- In combination with thermal storage and smart controls, heat pump-based systems can be used to shift electricity demand from time of shortage to a time of surplus, thus helping to stabilise the electric grid and allow larger shares of renewable electricity deployment.
- If deployed in combination with energy grids, they can be used in existing buildings too — the location of energy supply and the location of energy demand. The energy grid can also be used as a thermal storage and energy store from which heat pumps can generate useful heating or cooling.

With the multitude of benefits resulting from heat pump deployment, they can serve as 'integrator solutions' for a more renewable, balanced energy system. Heat pump technology is available for nearly all heating and cooling requirements in residential, commercial and industrial applications. They can be used in:

- New buildings
  - When building a new house, adhering to current energy efficiency standards makes the use of fossil combustion technologies for heating completely unnecessary. The energy demand is so low that it can easily be covered with renewable solutions. Energy plus houses become even net exporters of energy.
  - The same is true for any deep renovation. An upgrade of the building envelope results in savings of around 40%, in combination with a heating technology update, 70-80% of demand reduction is possible. If the remaining energy is provided from a renewable source, smart emission buildings become a reality. The example given applies to single and multi-family residences as well as to commercial buildings.
- Boiler replacement without touching the building envelope
  - In case of simply replacing an existing fossil boiler an opportunity for heat pumps arises, if the existing boiler is indeed overloaded. In this case, lower operating temperatures — as can be provided by heat pumps — are sufficient to provide end-user comfort. However, this requires a skilled installer overcoming the distance or installer to avoid disappointment.

The combination of district heating and heat pumps has a lot of benefit, as heat pumps can provide green energy to the thermal grid. They can improve the efficiency of existing grids by reducing the temperature on the return line and they can make low temperature excess heat from industry and buildings available to heating and cooling grids.

The Heat Roadmap Europe project provides a very good overview. Another innovative approach is currently being tested in the Ectogrid project, run by ELON in the city of Lund in Sweden. The concept connects buildings with different energy needs and balances the residual thermal energy flow between them.

It effectively uses and reuses all available thermal energy and makes it possible to decrease both pollution and energy consumption. The low temperature water loop that serves as a storage of a multitude of heat pumps provides heating and cooling to a whole building area. If successful, this concept can be replicated worldwide.

Both examples show the complementarity of large and small heat pumps in improving the energy efficiency of district heating and in greening them at the same time. With more than 300,000 new heating grids operating in Europe, there is huge potential.

What about lower carbon-than-coal natural gas — what sort of continuing role will gas play? It seems that the idea of ‘fossil gas’ being a cost-efficient solution for decarbonisation is very attractive to policymakers as it suggests that a business-as-usual approach can be taken to the challenge of renovating Europe’s building stock. It is augmented by the idea of combining the gas grid to distribute green energy from hydrolysis and ‘methanisation’ in the future.

However, fossil gas is not emission free. It has an emission value of 242 g of carbon dioxide per kWh of thermal energy. It is better than coal, but far away from clean. The disadvantage of promoting it will be that it will keep the need for a gas infrastructure in place and will slow down the necessary energy transition.

If a carbon price equivalent to today’s carbon dioxide price from the EU Emissions Trading Scheme (around €30/tone) would be applied to fossil gas boilers, an average user would have to pay an additional €180/year for the air pollution resulting from his/her gas consumption. With this very likely the most increasing in the future, it is not likely that any user can afford such a negative effect on his/her personal income. In sum, the combination of fossil-gas backed with a carbon price would make it more difficult for heat users to switch to heat pumps and for the transition to occur. It would make it more difficult for policymakers to decarbonise the energy system and the heat sector.

There is a political will to keep the gas grid because a win in the climate battle will also be a political win for the gas sector. The challenge for policymakers will be less about whether or not to switch to heat pumps, but rather how to make the switch happen. The support that can be made available to the switch will be of critical importance.

One way would be to offer incentives to end users to switch from gas to heat pump systems. This could be achieved in various ways:

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Austria’s capital city, Vienna, uses a 255 kW high temperature heat pump, providing district heating in the city. The heat pump uses the return line of the district heating grid as its supply temperature source. The heat pump achieves an annual coefficient of performance of 5.3.

Photo: Elona
buildings and in processes should be taken into consideration when planning new district heating systems or renovating old ones based on expected waste/excess heat supply. Current and future legislation aims at an energy demand reduction of 32% until 2030. This will certainly also impact available waste/excess heat.

Back to heat pumps – are we going to see many more water-sourced installations? And might there be a limit to available ambient heat? Currently, the heat pump market uses mainly air as an energy source. Out of 1.1mn heat pumps sold in 2017, nearly 90% use the energy stored in the standing air (aerothermal energy) to provide heating and cooling.

Water and ground-based solutions comprise the remaining 10%. Water is a very good storage medium for energy and thus, if large amounts of energy are needed, heat pumps using water as an energy source are very efficient. We do not expect a large increase in numbers, but we do observe an increase in installed capacity resulting in an increased supply of useful heat from water – either from open water ways or from ground water (hydrothermal energy).

This is also true for geothermal heat pump installations. All buildings that need to be supplied with larger amounts of heating will most likely be using hydrothermal or geothermal energy. If they need cooling, they can use water or ground for free cooling, or as a source for active cooling.

Is this energy source limited? I do not think so, as it is mainly solar energy that is replenished on a daily basis by the biggest fusion reactor we have – the sun.

Does Europe’s heat pump industry have the ability to expand to play the role discussed above? Yes. Over the last three years, annual sales have grown rather organically by 13%–15%. This growth can continue for a long time.

Our latest Market & Statistics report shows what is possible: 1.1mn heat pumps sold in 2017 generate 16.7 TWh of useful heat, 10.5 TWh of which is coming from a renewable source. The newly installed heat pumps save 2.7mn tonnes of carbon dioxide emissions and 19.5 TWh of final energy. At the same time, they provide between 1 and 3 TWh of demand-side flexibility to the grid, enabling more renewable electricity generation.

In terms of the stock, 10.6mn heat pumps installed generated 181 TWh of useful heat in 2017, 116 TWh of which came from renewable sources. They have saved 29.7 Mt of carbon dioxide emissions and 148 TWh of final energy.

If this market growth continues, a doubling of the European heat pump market by 2024 is realistic. Economies of scale will lead to reduced end-user prices which should further accelerate the deployment.

In the end, national governments and society as a whole will benefit. For governments, heat pump technology will help them to achieve the different energy and climate targets agreed to in EU policy; for society, the reduced emission from heating will lead to better air quality and help avert global warming and climate change.