Heating up the global heat pump market

Heat pumps are widely recognized as a key clean energy technology in the energy transition. While the global heat pump market has expanded significantly, more than doubling in some countries in a single year, expanded policy support will be needed to build confidence in the technology and meet climate goals.

Jan Rosenow, Duncan Gibb, Thomas Nowak and Richard Lowes

Heat pumps are a low-carbon heating technology with the potential to deliver large-scale reductions in carbon emissions from building heat. They use electricity to move heat from ambient outside air, water or ground to a building's interior and to heat water. This process is highly efficient, with heat pumps delivering three to five units of heat for each unit of electricity needed to run them[1]. In addition to being highly efficient, heat pumps also use predominantly renewable thermal heat rather than relying on combusting fossil fuels. As much of the useful heat from a heat pump comes from inexhaustible environmental sources, 70–80% of energy provided by an average heat pump is renewable. Even with today's electricity mix, which tends to include fossil fuels such as coal, heat pumps can reduce emissions in most of the world's regions, which together made up 96% of global heating energy demand in 2015 (ref. [2]). When the electricity used to drive the electric compressor is produced from low-carbon sources, nearly all of the useful heat provided becomes low or even zero carbon[1–4].

Heat pumps have been repeatedly identified as a key, cost-effective solution for tackling the carbon emissions associated with keeping buildings warm at international[5,6], regional[7,8] and national levels[9–11]. The costs of low carbon electricity have also declined significantly over the last decade, bolstering the case for electric heat pumps[12].

Sales of the technology, however, have remained modest in many countries[13]. Europe has been leading the shift, with double digit growth rates from 2015 onwards[14]. Other countries, including China, are seeing comparable developments more recently[15]. Similar to the market for electric vehicles, the increasing recognition of this technology in energy strategies and the growing use of clean heating are expected to lead to much faster and potentially much more significant deployment and use of heat pumps around the world.

Current deployment of heat pumps

Globally, 177 million heat pumps had been installed by 2020, according to the the International Energy Agency's (IEA) data (Fig. 1). Most of these heat pumps were in China (33%), followed by North America (23%) and Europe (12%). Until recently, however, the heat pump market has been growing far more slowly than required by the IEA or the UK's Committee on Climate Change (CCC) decarbonization scenarios[5,9]. This is evident from the IEA's global heat pump stock figures[16]: at current rates, only 253 million heat pumps would be installed globally by 2030, compared with the 600 million units needed by that year in the IEA's net-zero scenario — a shortfall of 58% (see Fig. 1). This includes air-to-air, air-to-water, water-to-water and ground-to-water heat pumps.

Interestingly, the highest penetration of heat pumps can be found in the coldest climates (Fig. 2), despite frequent claims in parts of the media that heat pumps do not work in cold climates. In Europe, the four countries with the largest share of heat pumps are Norway (60% of households), Sweden (43% of households), Finland (41% of households) and Estonia (34% of households). These four nations also face the coldest winters in Europe, as indicated by the number of heating degree days (defined relative to a base temperature — the outside temperature above which a building needs no heating). This heat pump leadership has been in part attributed to the high historic prevalence of oil heating in these countries and a strategic response to oil price crises by reducing oil for heating[17].

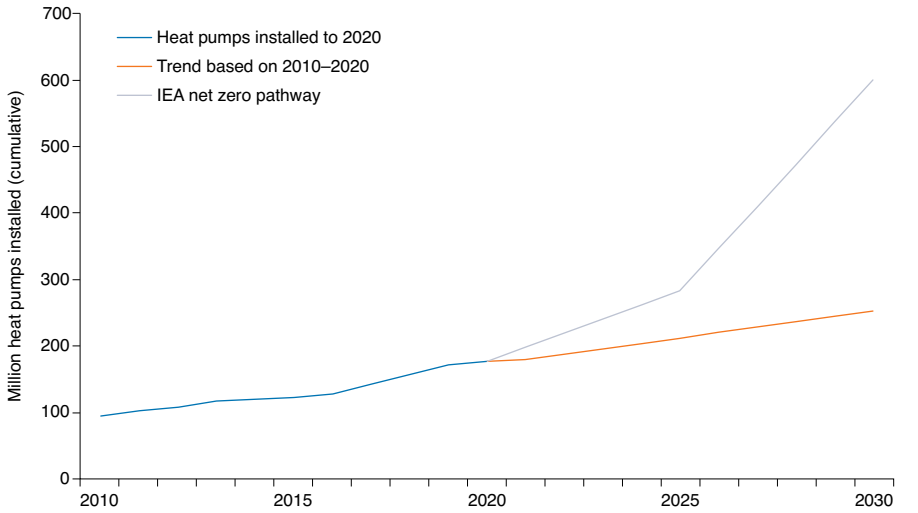

Fig. 1 | Global historic heat pump sales and IEA net zero 2050 pathway. Global stock of heat pumps through to 2020 (blue line) and growth to 2030 under a continuation of past trends (orange line), versus the number of units installed under the IEA's net-zero pathway (grey line). Credit: Blue line from[16], orange line projection based on market growth rates in[16] and grey line from[5].

Market trends

Despite the steep increase in deployment needed to meet future scenarios, there was only modest growth for heat pumps in 2020 in key markets around the world. In 2020, IEA data[16] shows that the global heat pump market grew by just 3%.

The sluggish growth can be primarily explained by the global COVID-19 pandemic and the related decline in economic activity. Before that, the market had been growing by around 10% per year. The IEA's net-zero pathway requires market

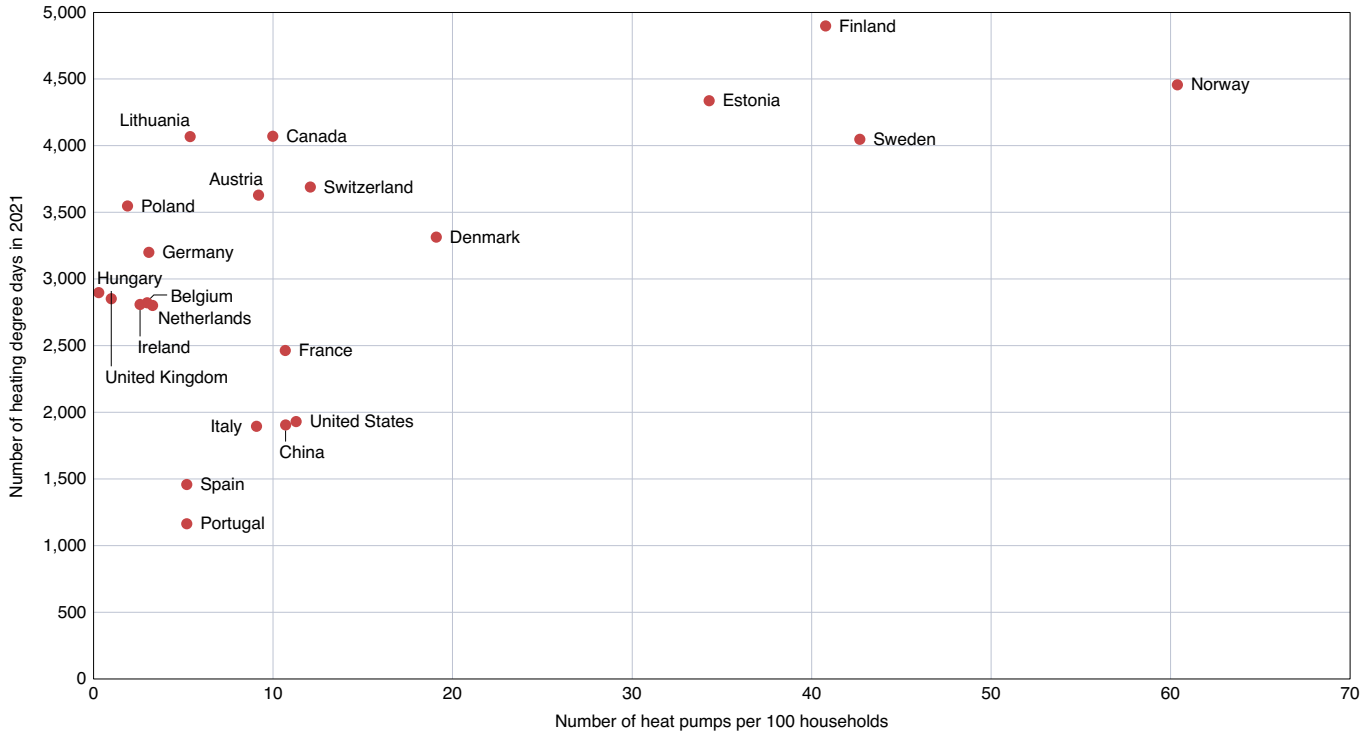

Fig. 2 | Heat pump penetration and number of heating degree days in 2021 in selected countries. Figure shows how colder countries (more heating degree days) tend to have higher levels of heat pump penetration. Number of heating degree days is a population-weighted average with a reference temperature of 18 °C from[31]. Heat pump penetration shows the number of heat pumps existing per 100 households in selected countries in 2020. Data is taken from[14,18,22,32–38].

growth at a global level of around 13%, year on year to 2030.

However, following the slowdown in 2020, initial data for 2021 suggests the heat pump market saw a strong recovery over the year, with double-digit growth in some of the countries where figures are available. Across Europe, the European Heat Pump Association (EHPA) observes market growth to have exceeded 34% in 2021, surpassing 2 million units sold per year for the first time[14]. The 2.17 million units sold in Europe break down into 1.93 million heating units and 0.24 million hot water heat pumps. Of these, 94% use air and 6% use the ground or water as their energy source. The biggest gains in heating and hot water heat pump sales were recorded in the Netherlands, France, Italy and Germany.

In China, the world's largest market for air source heat pumps, sales grew around 7% to reach 12.5 million units in 2021 (ref. [18]). Clean heating in China has been driven by the country's use of policies enforcing technology mandates, such as its Clean Winter Heat Plan in Northern China and its Electric Heating Policy, which requires the substitution of coal-fired heating with electric heating[19]. These efforts have been bolstered by local financial incentives, such as in Beijing, that support heat pump deployment[20]. In addition, China's efforts to improve air pollution through its Clean Air Act also supported the heat pump market[21].

In the USA, another major market for air source heat pumps, sales in 2020 of air-source heat pumps were higher than gas furnaces for the first time. This trend continued in 2021 with market growth of 15% in 2021, capping a run of consistent yearly growth above 5% since 2015 (ref. [22]). Varying by building type, around 40–50% of new buildings install heat pumps as their heating device[23]. Heat pump installations in the United States have been in part driven by an array of tax credits (between 20–30% of system cost) that support air-source and geothermal heat pump deployment[24].

Discussion

Although further rapid growth now looks likely, the pace of adoption — and how that measures up against pathways to net-zero — will depend strongly on government policies and energy price trends. The recent increase in European and Asian gas prices increases the attractiveness of heat pumps compared to gas boilers. But that could change. Sustained policy support thus remains vital for heat pumps which, in most contexts, are not the dominant heating technology.

The experience from selected countries with significant heat pump deployment suggests that a number of policy practices are particularly effective.

First, policymakers should ensure that there is a clear financial incentive for building owners to invest in heat pumps. The cost of heat pumps is made up of two elements: capital costs and running costs. In general, heat pumps have higher upfront costs than fossil-fuel alternatives, and transition costs are particularly high for the first-time switch from a fossil-fuel system to a heat pump. Providing building owners with subsidies, for example through grant programmes, tax rebates or low interest loans, can help reduce their upfront costs. Such financial instruments have been used for example in China[20], the UK[25], Norway[26], Finland[25], Switzerland[13], Germany[27], and several states in the USA. The main running costs (associated with electricity used by the heat pump) will be determined by the cost of electricity, the efficiency of the heat pump, and the overall heat demand of the building. Increasing taxes on fossil fuels can reduce the cost differential regarding running costs. Sweden, Norway and Finland have taken this approach[28]. The removal of taxes and levies from electricity can further improve the business case for heat

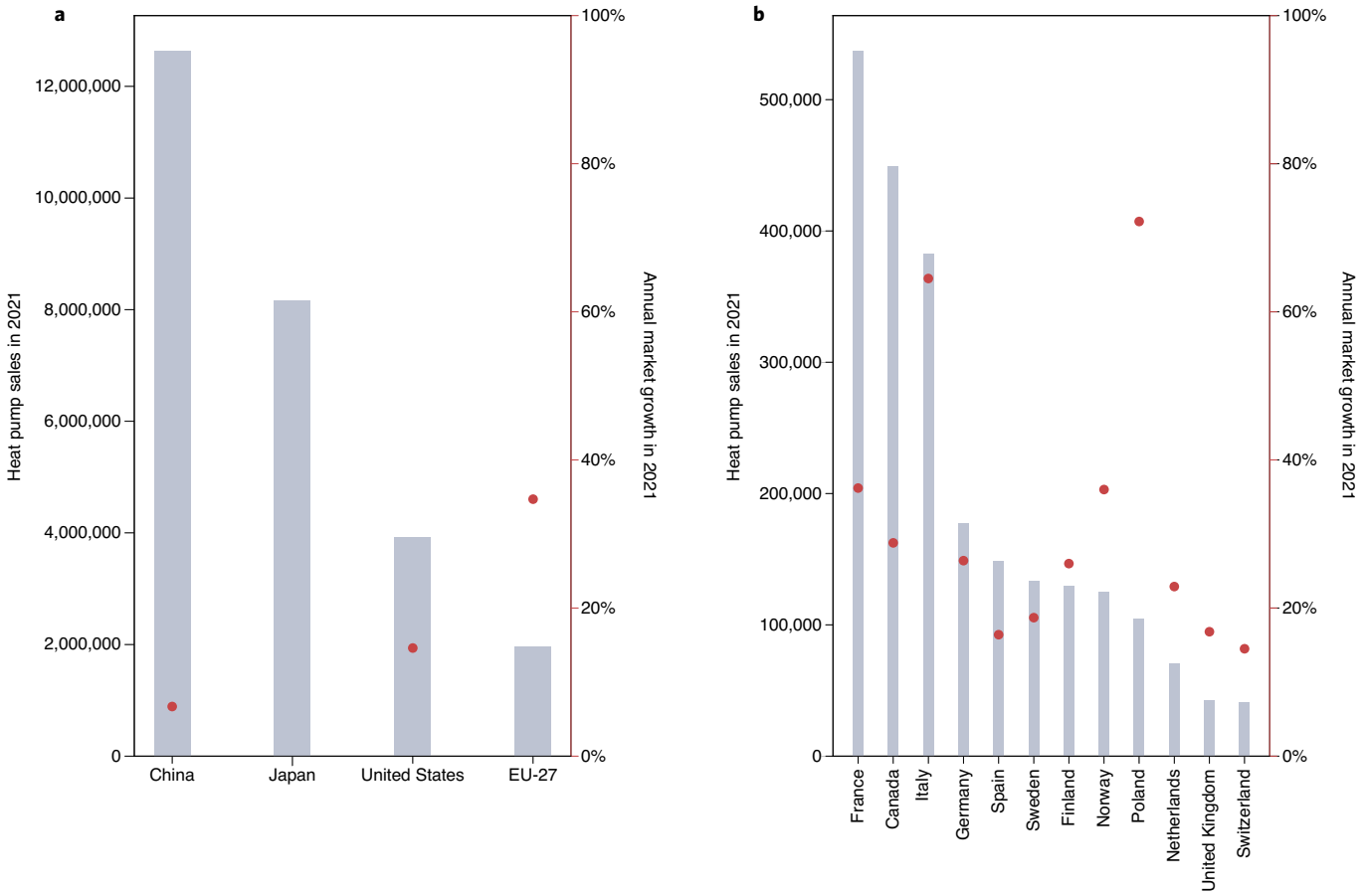

Fig. 3 | Air-source heat pump sales and market growth in key markets in 2021. Figure shows sales and annual growth of air-source heat pumps in markets above 1,000,000 annual sales (**a**) and leading markets where data is available (**b**). Annual sales are shown as grey bars on left axis and the observed market growth in each country is shown as red dots on the right axis. Japan's market contracted 5% in 2021, thus its negative growth is not portrayed here. Data is taken from[14,18,22,32–38].

pumps, particularly where those costs make up a high share of the final electricity bill. Countries that have done this include for example Denmark, the Netherlands, and, most recently, also Germany[29].

Second, while pricing and subsidies are clearly important elements of the policy picture for heat pumps, other policy options, broadly categorized into 'regulatory' measures, are needed to support heat pump deployment at a scale consistent with climate goals. Such measures include building standards, renovation standards, appliance performance standards, and outright bans on fossil-fuel appliances. Variations of all of these already exist in countries such as the USA, the UK, Germany, the Netherlands, Belgium, Sweden, Norway, Finland, Denmark and many others. In some cases, such as in the Netherlands, hybrid systems (heat pump plus fossil fuel heating system) are still being allowed to provide building owners with more flexibility. When using such regulatory measures, it is important to announce them well in advance so that consumers and the supply chain can prepare.

Finally, building trust and consumer confidence is essential in less mature markets. This is what experience in Sweden, for example, shows clearly[17]. In Sweden, information campaigns, high training standards for installers, technical standards of the installations and equipment, and mechanisms for customer complaints were all part of changing the perception of heat pumps from an unfamiliar and potentially risky technology to a mainstream heating system option.

What experience tells us is that the expansion of heat pump markets historically happened in the context of a supportive policy mix combining economic incentives, regulation, research and development, training, and information campaigns rather than one single policy instrument driving market uptake[17,30]. An effective policy mix typically combines financial instruments (such as financial support in the form of grants, tax reductions and loans, carbon taxes, and supportive energy pricing policies) with measures to support consumer confidence, including cross-sector heat pump associations and promotional campaigns, technical standards and skills. Additionally, building regulations and appliance standards are used to phase-out fossil fuel heating and/or mandate clean heating technologies, including heat pumps.

Conclusions

Maintaining the annual growth rate of new heat pump installations at sufficient levels is the main challenge for countries around the world. It will require the continued expansion of policies to support heat pump rollout and to reach the concentrations necessary to reach net zero by 2050 — and to contribute to limit warming to 1.5 °C. Recent policy announcements, including bans of fossil fuel heating, mandates for heat pumps and pricing reform, suggest that policy makers have understood and are willing

to provide markets with the necessary technology clarity to ensure that heat pump installation rates will increase further in future years. Recent market expansion instils confidence that more rapid deployment of heat pumps is feasible if supported by well-designed policies Fig. 3. ❐

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Competing interests

J.R., D.G. and R.L. declare no competing interests. T.N. is the Secretary General of the European Heat Pump Association, which represents the European heat pump industry.