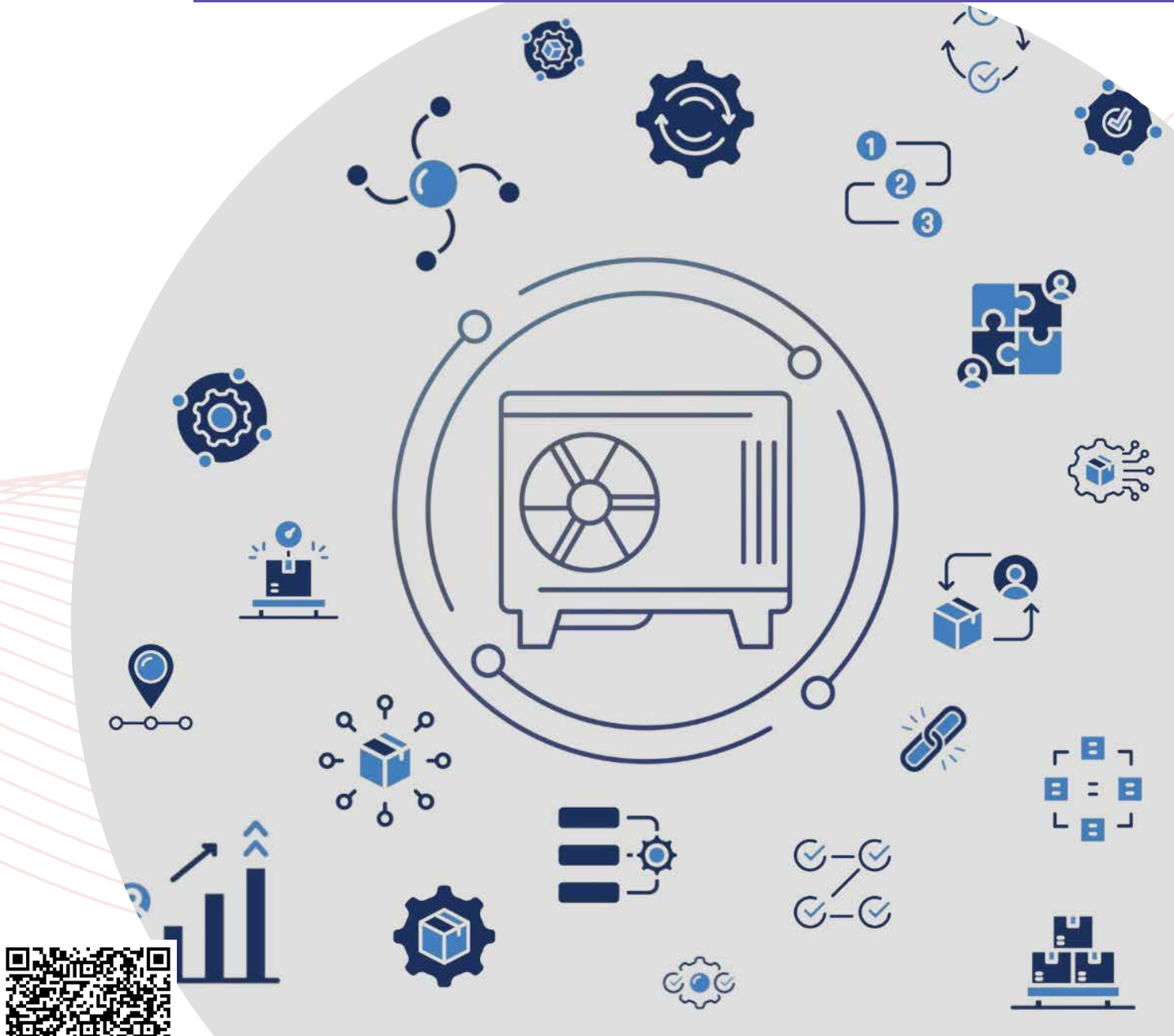


TAKING THE TEMPERATURE OF THE EU'S CLEAN INDUSTRY STRATEGY

COMPETITIVENESS AND RESILIENCE OF HEAT PUMPS

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EXECUTIVE SUMMARY

Europe's decarbonisation-competitiveness debate has placed industrial policy at the centre of the EU's policy agenda. Since the Draghi Report of September 2024, a succession of EU initiatives – the Competitiveness Compass, the Clean Industrial Deal and now the Industrial Accelerator Act (IAA) – have sought to reconcile decarbonisation with competitiveness, including through “Made in Europe” requirements expressed at the level of individual components. This study takes the heat pump industry as a case study to identify which components should be prioritised for support to accelerate EU manufacturing, progress towards decarbonisation targets and regain competitiveness.

The analysis examines five core heat pump components – compressors, heat exchange units (HEUs), fans, controllers and refrigerants – across four dimensions: production levels; international competitiveness; trade balances and import dependencies; and innovation capacities. It draws on disaggregated trade and production data, desk research and interviews with nine industry stakeholders and experts, benchmarking the EU against China, the USA and Japan.

Four key findings emerge. First, EU production is highest for HEUs and compressors and remains concentrated in large Western European economies, though Central and Eastern European countries are playing a growing role. Second, HEUs have the strongest and most solid export profile. However, the EU as a whole faces intensifying cost-based competition, particularly from China, which is also upgrading to higher-value segments. Third, the EU is competitive for several components and particularly strong for HEUs but remains dependent on imports for compressors and certain refrigerants. Fourth, innovation across the value chain is largely incremental, reflecting the maturity of the underlying technologies. The EU holds a leading innovation position for HEUs, while compressors are its weakest

area, with intellectual property concentrated in Japan and the USA. Regulatory pressure, particularly around the shift to natural refrigerants, is a strong and distinctive driver of EU innovation.

The main policy recommendations of this study are as follows:

1. **Industrial policy should prioritise components that can deliver manufacturing capacity, jobs, innovation and added value**, not attempt to restore cost competitiveness in standardised, low-value segments.
2. **HEUs emerge as the clearest candidate for an assertive industrial policy**, including Made in Europe requirements, given the EU's combination of production capacity, competitiveness and innovation leadership.
3. **Compressors are a harder target for expanding manufacturing capacity, but still warrant policy support** to protect existing EU capabilities and niche strengths.
4. **Continued regulatory ambition**, particularly on natural refrigerants, remains one of the EU's most powerful tools for sustaining its competitiveness and innovation edge.
5. **Any policy mix should combine demand-side incentives** to stabilise adoption **with conditional supply-side support** for EU producers, backed by effective **policies to promote skill creation and avoid skill shortages**.

1. INTRODUCTION

The question of Europe's competitiveness has become the centre of the EU policy agenda. Aligning competitiveness policies with the clean industry agenda is essential for effective and lasting advances on both fronts. The Draghi Report¹ argued that Europe must not only accelerate its transition to carbon neutrality but also ensure that this transformation strengthens, rather than undermines, its global competitiveness. As the EU will need more net-zero products and technologies to meet its ambitious climate targets, a strategy to strengthen clean manufacturing capacity in Europe is essential to reap the benefits of the transition. The decarbonisation-competitiveness plan proposed by Draghi calls for a strategic reorientation of industrial policy: reducing external dependencies; reinforcing domestic production capacities; and fostering innovation in clean technologies.

In this context, clean technologies offer substantial opportunities for investment, job creation and innovation, providing a window of opportunity for Europe to regain competitiveness and reindustrialise.² However, at this juncture, competitiveness and technological sovereignty in advanced technologies are at risk: having never closed the gap with the USA in digital technologies, Europe risks losing its edge in green technologies too, a particularly regrettable prospect given that it was Europe that pioneered clean technologies in the first place. **Evidence related to the adoption of clean technologies in Europe points to increasing reliance on Chinese imports,** with industries such as solar photovoltaics illustrating this dynamic vividly.

Therefore, **advancing the clean industrial agenda without pairing it with a competitiveness strategy would deepen strategic dependencies.** This agenda seeks to spur demand for clean technologies (e.g., by subsidising their adoption), but, without strong clean technology manufacturing in Europe, Chinese imports will likely meet this increased demand. In

other words, the EU's climate neutral industrial agenda could create more economic benefits and promote competitiveness elsewhere, deepening EU trade imbalances. Addressing this challenge will require industrial policies to (1) strengthen EU manufacturing to meet the climate targets where Europe can feasibly pursue this strategy, and (2) de-risk (i.e., reduce dependency on a single country) by diversifying trade partners where Europe cannot become a credible producer.

To operationalise this agenda, the European Commission released the Competitiveness Compass and the Clean Industrial Deal in early 2025. The former is a road map to restore Europe's economic dynamism, building directly on Draghi's recommendations by identifying priority areas for reform, simplifying decision-making, and aligning industrial policy with the twin green and digital transitions. The Clean Industrial Deal took a further step toward operationalising the decarbonisation-competitiveness agenda by focusing on scaling up clean technology manufacturing within the EU. It aims to ensure that Europe not only deploys climate-friendly solutions but also produces them, thereby reducing reliance on imports and strengthening resilience. **More recently, the Industrial Accelerator Act (IAA) proposed measures to accelerate industrial capacity and decarbonisation in net-zero technologies.** The IAA marks a shift from general plans to concrete policy instruments and targets for selected value chains that identify which components should be produced in Europe. With the IAA, the European Commission seeks to define which components of clean technologies must be of EU origin and, therefore, be supported by "Made in EU" requirements.

To contribute to these discussions and policies, the study takes the heat pump industry as a case study. The IAA specifically references heat pumps: it notes that EU production depends heavily

on non-EU components and that dependency risks growing without “decisive action”. While the IAA breaks down most of the promoted net-zero technologies into specific components with component-specific requirements, it currently deals with heat pumps as one final product. However, heat pump manufacturing and supply chains depend on the availability and competitiveness of a range of different components. Therefore, this study **identifies which heat pump components should be supported to accelerate manufacturing production in the EU**. To do so, it collects highly detailed data to analyse the EU’s competitiveness, resilience and innovation performance at the component level. While the analysis is developed for heat pumps, it can be extended to other green technologies and enrich discussions on how to operationalise the Made in Europe agenda.

Beyond being the object of current policies, heat pumps are a particularly relevant technology for various reasons. First, they are widely recognised as a cornerstone of Europe’s decarbonisation pathway, offering an efficient alternative to fossil-fuel heating in residential, commercial and industrial applications. They contribute directly to emissions reduction in the construction sector, which is one of the most energy-intensive parts of the European economy. Beyond the construction sector, industrial heat pumps can also contribute to decarbonising energy-intensive industries.³ Second, unlike other clean technologies such as solar photovoltaics, the heat pump industry also has incredible potential, as EU firms still produce the majority of heat pumps sold domestically, with shares between 60 and 70%.⁴

In addition, the heat pump industry is a particularly interesting market because of its prospects. Investments in new production lines have accelerated. Projects announced amount to approximately €7 billion for the period 2020-2030.⁵ Moreover, the EU hydronic heat pump production capacity could reach nearly 5 million units annually by 2026 and about 8 million units by 2030.⁶ This would allow the EU to meet its REPowerEU targets of installing 30 million additional units by 2030, provided announced investments are delivered. Despite significant growth, there is still room to

increase heat pump adoption in the EU. As of 2023, more than 21.5 million heat pumps were installed in the EU, representing only a fraction of the total market. Beyond gaps in policy, funding and regulatory stability, adoption is also slowed by the perception that heat pumps are an unproven technology, whereas in practice the technology is mature.⁷

At the same time, the industry illustrates the challenges of competitiveness: while European firms remain strong in certain components and niche markets, their competitiveness is eroding and increasing production would require scaling up component manufacturing. The heat pump industry, therefore, provides a concrete lens for examining the balance between climate ambition and industrial resilience. **Continued growth in the heat pump market will require a significant scale-up of component manufacturing,**⁸ a point also made more generally by Draghi.⁹ While unutilised capacity is available at existing factories, it would not be sufficient to meet the projected surge in demand and ensure Europe’s resilience and competitiveness in the medium term, amid increased pressure from Chinese competition.

Identifying which components to prioritise, based on where EU manufacturing could realistically be created or expanded, requires a more granular analysis than existing studies offer. This study contributes precisely to this aim by collecting and analysing highly disaggregated data on the main components of a heat pump, namely, compressors, heat exchange units (HEUs), controllers, fans and refrigerants. To determine which components the EU should target from a strategic perspective and which ones it can feasibly produce within the EU, the analysis focuses on four dimensions: production levels; international competitiveness; trade balances and import dependencies; and innovation capacities. In doing so, this study complements and deepens the analysis in other reports¹⁰ by providing a clear understanding of the markets for the key components.

2. UNDERSTANDING HEAT PUMPS: COMPONENTS AND TECHNOLOGICAL DIRECTIONS

2.1 A heat pump and its components

A heat pump is a “device that can provide heating, cooling and hot water for buildings, districts and even for industry”.¹¹ Heat pumps work by transferring heat from a lower-temperature source to a higher-temperature sink using electricity. Rather than generating heat by combustion, as a boiler does, a heat pump moves thermal energy that already exists in the environment. This makes it highly efficient technology, delivering more thermal energy than it consumes in electrical energy.¹² When heat pumps are powered by renewable energies, their operation is carbon neutral. Different types of heat pumps are available on the market, depending on size, use (domestic versus industrial), heat source and the medium through which they deliver heat (see Box 1 for characterisation details).

BOX 1. DIFFERENT TYPES OF HEAT PUMPS.

The most basic distinction of heat pumps is size. Heat pumps are considered “large” if they exceed capacities of 100 kW. The largest units provide 35 MW for a single machine. Large-scale installations are tailor-made, while smaller installations are more standardised.¹³

Heat pumps are also classified by their heat source and by the medium through which they deliver heat.¹⁴ Table 1 summarises the five main types of heat pumps. Systems that deliver heat through water circuits, including air-to-water, ground-to-water and water-to-water configurations, are collectively known as hydronic heat pumps. These systems transfer heat to

water that circulates through radiators, underfloor heating or storage tanks, making them compatible with existing building infrastructure and district heating networks.¹⁵

Industrial and large-scale heat pumps operate on the same thermodynamic principle but at higher capacities (above 1 MW) and temperatures that can exceed 160°C. These units are increasingly integrated into district heating and cooling networks, where they recover waste or ambient heat from industrial processes, wastewater or natural water bodies.¹⁶

The efficiency of a heat pump is measured by its coefficient of performance (COP) – the ratio of heat output to electrical energy input. Under European conditions, residential air-source systems typically achieve COPs between 2.5 and four, while ground- or water-source systems often exceed four because of their more stable source temperatures.¹⁷

Source: Vienna Institute for International Economic Studies (wiiw).

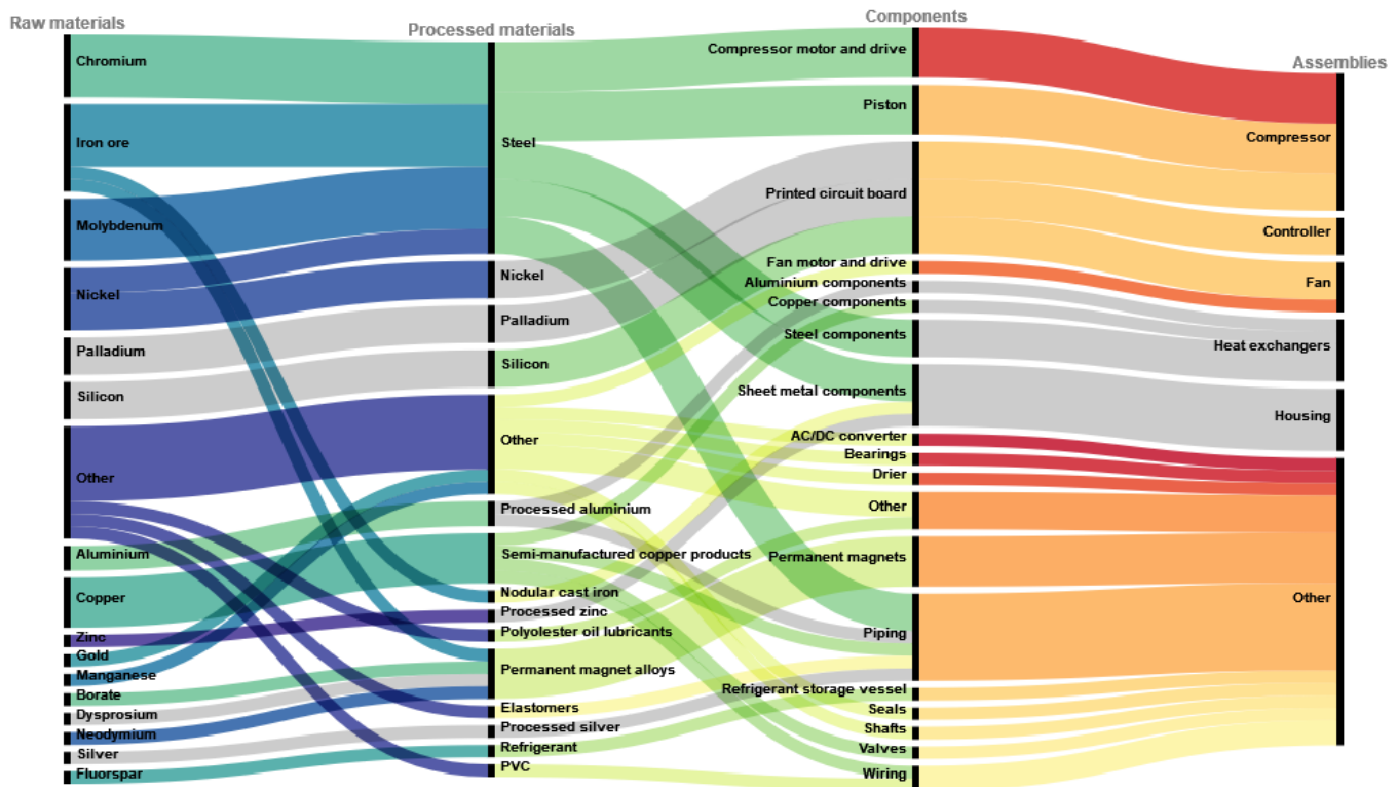
Table 1. The different types of heat pumps currently available.

Type	Heat source	Heat sink (delivery medium)	Typical application
Air-to-air (AAHP)	Ambient air	Indoor air	Residential space heating/cooling
Air-to-water (AWHP)	Ambient air	Water circuit	Space heating and hot water
Ground-to-water (GSHP)	Sub-surface geothermal energy	Water circuit	Space heating, colder climates
Water-to-water (WSHP)	Surface or groundwater	Water circuit	District heating or industry
Hybrid systems	Air/ground + auxiliary boiler	Water or air	Flexible or backup operation

Source: authors' elaboration.

Figure 1 illustrates the flow of materials and components of a heat pump, from raw materials to processed materials, subcomponents and final assemblies. As the figure shows, producing a heat pump requires a variety of raw materials, including steel, a key input for basic components such as compressor motors and pistons. In turn, these components are put together in “assemblies” – the most important of which are compressors, controllers, fans, HEUs and the housing.¹⁸ Most of these components are not specific to heat pumps, indicating a high degree of component commonality with other products.¹⁹ By contrast, components such as scroll compressors and four-way valves are specifically manufactured for heat pumps.²⁰

Figure 1. The entire value chain of heat pumps.



Source: Toleikyte et al. (2023: p. 40).

Each of a heat pump's key components presents distinct characteristics that have implications for EU competitiveness:

1. **Compressors** are the most critical component of a heat pump, representing between one quarter and one third of the total unit cost and largely determining its performance, especially in terms of the efficiency of the system.²¹ While some compressors are used for other products, certain compressors, most notably scroll compressors, are specifically designed for heat pumps.
2. **HEUs** (evaporators and condensers) account for 15% of the unit's value.²² These are generally standardised components used in other products. Their production requires a complex thermal design, advanced materials and precision manufacturing.
3. **Electronics and controls:** modern heat pumps rely on electronic controls, sensors and circuit boards to achieve high efficiency, which depend heavily on semiconductors.
4. **Fans, pumps and ancillary components** (i.e., storage tanks and buffer vessels) are less technologically complex than core components such as compressors or HEUs.
5. **Refrigerants:** traditionally, the principal refrigerants used in heat pumps include hydrofluorocarbons (HFCs), such as R410A, R134a or R32.²³ Under the F-gas Regulation of 2024 (see Box 2), the EU will phase out HFCs by 2050, encouraging a shift to natural refrigerants such as propane (R290), ammonia (R717) and CO₂ (R744).²⁴ In particular, propane is likely to become the new standard in residential applications, and ammonia may be

viable only for the industrial market, given its scalability and higher toxicity. Regardless of the specific natural refrigerant, the switch creates costs for firms, as production lines must be adapted and new safety and certification standards must be met, particularly because of its risks and toxicity levels. In the long run, however, this transition may provide an advantage if global markets move in the same direction. Uncertainty around potential per- and polyfluoroalkyl substances (PFAS²⁵) restrictions under the REACH Regulation (see Box 2) adds another risk, since some refrigerants and related chemicals could be affected.²⁶

BOX 2. THE LEGISLATION AFFECTING REFRIGERANTS FOR HEAT PUMPS.

Heat pump refrigerants are mainly affected by the F-gas Regulation, but some of them are also likely to become regulated under the new REACH Regulation, which is currently under revision.

The **EU F-gas Regulation** was originally adopted in 2014 (Regulation (EU) No 517/2014) to support the implementation of the Montreal Protocol on Substances That Deplete the Ozone Layer, the landmark multilateral environmental agreement regulating the production and consumption of nearly 100 man-made chemicals. The 2014 Regulation aimed to reduce the use of fluorinated greenhouse gases (F-gases), around 90% of which are HFCs, and played an important role in shaping the Kigali Amendment to the Montreal Protocol. To date, 171 countries have ratified the Kigali Amendment, committing signatories to a phased reduction in global HFC production and consumption by 80-85% by the late 2040s.

The EU F-gas Regulation was subsequently revised, most recently through Regulation (EU) 2024/573, which entered into force in March 2024. The revised Regulation significantly accelerates the HFC reduction schedule, requiring a 95% reduction in F-gas consumption by 2030 compared with the baseline and establishing a complete phase-out of HFCs by 2050. To achieve this, the Regulation introduces progressively stricter quota reductions for HFCs placed on the EU market, measured in CO₂-equivalent terms, culminating in a final phase-down to zero by 2036: 23.9% of the baseline level during 2024-2026; 14.8% during 2027-2029; and 8.9% during 2030-2032. Alongside these quota reductions, the Regulation introduces a range of sector-specific restrictions and product bans, thereby imposing more ambitious requirements than those set out in the Kigali Amendment.

In its current form, the **REACH regulation** (EC 1907/2006) does not regulate the use of R410A and R134a. The European Commission is currently revising the Regulation and, in 2023, a proposal was submitted to restrict PFAS, including refrigerants R410A and R134a. While the definition of PFAS in this proposal is quite broad (thus calling for extensive restrictions and potentially creating tension with the current version of the F-gas Regulation), it is not yet clear which definition of PFAS will be adopted by the revised REACH regulation. R410A and R134a could be derogated should the definition adopted in the new REACH be narrow (i.e., allowing for substances with only limited PFAS content, e.g., only one component). At this stage, no other chemical refrigerants are completely free of PFAS. Hence, natural refrigerants appear as the most long-term solution for sustainability.

Source: wiiw.

In terms of cost structure, components and materials dominate production costs (60-85%), favouring countries with competitive and well-integrated heat pump component manufacturing and access to materials.²⁷ At the component level, existing analysis shows that **the compressor and electronic controls account for around half of the total unit value of a typical air-source heat pump** (roughly 25% each), followed by HEUs (around 15%) and housing (around 13%), with fans, pipework and refrigerants each representing a comparatively small share of the heat pump's unit cost.²⁸ Stakeholders confirm that, while prices vary widely by application, a compressor represents 25% of a heat pump's price, followed by a HEU (between 8% and 13%) and fans (7%).

Assembly accounts for a relatively high share of a heat pump's value and that of its components. According to estimates from stakeholder consultations, assembly can account for about 18-30% of the value of a heat pump, with the share depending on the size, use and complexity of the final product (e.g., for residential or industrial use). Similarly, assembly of compressors comprises about 25-30% of the value of a final compressor. Labour costs make up 5% of total production costs.²⁹

According to some estimates, **reshoring the production of these compressor subcomponents to the EU would imply a 40-50% cost increase for the final compressor.** This cost increase is not only due to higher labour costs in the EU, but also to logistics costs, as some subcomponents would still need to be imported from China for assembly in Europe. **HEUs also face a similar situation**, with 70% of components manufactured in China and assembly carried out in the EU.³⁰ The situation is different for HEUs, where the most important EU producers also manufacture subcomponents in Europe.

Box 3 further illustrates the criticality of different components for the overall functioning of a heat pump.

BOX 3. THE ROLE OF EACH COMPONENT IN THE OPERATING PROCESS OF HEAT PUMPS.

The operating principle is the vapour-compression cycle, which is the same process as that used in refrigeration and air conditioning. The cycle has four key phases:³¹

1. **Evaporator** – a HEU where the refrigerant absorbs heat from a low-temperature source, such as air, water or the ground, and evaporates. In a typical residential operation, about 70-80% of the heat delivered by a heat pump comes from the ambient source, while about 20-30% is supplied to the compressor as electricity. Environmental heat is considered renewable because it is naturally replenished, although sustainable extraction depends on local conditions and system design.³²
2. **Compressor** – the refrigerant gas then reaches the compressor. Powered by electricity, the compressor raises the refrigerant's pressure and temperature. The energy required by the compressor accounts for approximately 20% of the total energy required to operate the heat pump.
3. **Condenser** – the second HEU in the heat pump is called the "condenser". Through the condenser, the hot, pressurised refrigerant releases heat to the building's heating circuit or to an industrial process and condenses back to a liquid.
4. **Expansion valves** reduce the refrigerant's pressure, cooling it before it re-enters the evaporator and starts a new cycle.

This closed loop enables the system to extract ambient heat – even from cold air or ground – and „upgrade“ it to a useful temperature for space or water heating.

Source: wiiw.

2.2 The technological trajectories of heat pumps

Existing assessments consistently describe heat pumps as a mature and commercially proven technology, particularly for residential and commercial applications.³³ Air-to-air and air-to-water systems are now widely standardised, with global manufacturers producing millions of units annually. As a result, competition in these market segments increasingly centres on price, reliability and installation costs, rather than on core thermodynamic innovation. This maturity favours large-scale producers, who benefit from economies of scale and integrated supply chains.

Still, the heat pump technological trajectory is not yet saturated: opportunities for innovation remain substantial. Technological change is moving toward superior performance and lower cost. In addition, noise reduction, compactness and life-cycle material efficiency represent emerging design priorities. For noise reduction, compressors are particularly important, as they are the dominant noise source in most heat pump systems.³⁴ Noise reduction efforts also target fans, with optimising sound emission being among the most important issues.³⁵ In terms of compactness, HEUs are typically the largest component by volume in a heat pump unit, making them the main target for size reduction. They are also among the most material-intensive components in terms of both weight and cost. They are typically made from copper or aluminium, both energy-intensive and strategically significant materials. Copper is increasingly perceived as problematic due to limited access (driven by the demand surge and other factors, including US tariffs) and lower recycling potential. In this regard, microchannel heat

exchangers (MCHEs) could make a big difference by reducing the amount of aluminium or copper required, impacting sustainability.

Regarding the typologies of heat pumps and their components, research and development and innovation (R&D&I) focus on the following:³⁶

1. higher-temperature industrial heat pumps, capable of operating up to or above 160°C;
2. system integration and digital optimisation, such as smart controls, grid-interactive operation and coupling with thermal storage or photovoltaics;
3. natural refrigerants, particularly propane (R290) and carbon dioxide (CO₂ or R744), which require new safety and control designs, due to either higher flammability or higher operating pressure; and
4. HEUs and compressors (e.g., electrochemical and 3D-extruded compressors), with new safety standards as the industry transitions to new refrigerants.

Beyond these incremental advances, a new generation of non-vapour-compression heat pump concepts is under laboratory and pilot-scale development. These include magnetocaloric, electrocaloric, elastocaloric, thermoelectric and thermoacoustic heat pumps, which replace the conventional vapour-compression cycle with solid-state or acoustic processes. Such technologies currently show low technological readiness levels (TRLs), between three and six, and remain far from commercial maturity.³⁷ At this stage, these products are also very expensive, and some have relatively limited applications; therefore, they are produced at reduced scales, or their scalability is a concern. Nevertheless, they represent long-term avenues for improving efficiency, eliminating refrigerants and reducing environmental impacts.

Industrial and district heating applications, many of which remain at TRLs between six and eight, also continue to evolve through EU-funded

demonstration projects.³⁸ Moreover, studies on the potential of industrial heat pumps³⁹ and geothermal systems⁴⁰ confirm that raw material and refrigerant choices significantly affect both competitiveness and environmental performance.

Hence, although the residential heat pump technology is largely mature, the broader heat pump technology still offers meaningful scope for innovation and technological differentiation, particularly where efficiency, environmental performance and system integration play a significant role. The circularity potential of heat pumps is increasingly recognised as part of their contribution to resource efficiency. Heat pumps typically have a lifespan of around 15 years, depending on the type, maintenance and operating conditions, meaning that end-of-life flows will grow substantially as the current wave of installations matures.⁴¹ Most units contain significant amounts of recoverable metals such as copper, aluminium and steel, as well as compressors and HEUs that can be refurbished or remanufactured. Although dedicated end-of-life collection and recycling schemes for heat pumps are still limited, the reuse of materials and components could substantially reduce primary resource demand and embedded emissions if proper infrastructure and standards are established.⁴² Improving circularity also depends on the safe recovery and recycling of refrigerants and on designing systems for easier disassembly and repair.⁴³

3. THE EU HEAT PUMP INDUSTRY: AN OVERVIEW OF THE RECENT PERFORMANCE

3.1 Production of heat pumps and their components

Europe has a long tradition of heat pump manufacturing that dates back to the 1970s, when the oil crisis spurred interest in alternative heating technologies. Early pioneers included Swedish and Swiss firms that developed ground-source systems for residential heating, as well as German and Italian manufacturers who adapted refrigeration technologies for domestic use.⁴⁴ During the 1990s and 2000s, production expanded across Northern and Central Europe, supported by policy incentives for renewable heating and the growth of national installer networks.⁴⁵ Countries such as Germany, Italy, Sweden and France became important manufacturing hubs, and a dense network of suppliers and service companies developed around them.

Today, Europe remains a leading global producer of heat pumps. Between 60 and 73% of all heat pumps installed in the EU are also manufactured within the Union, meaning that the final products are assembled within the EU (see Box 4).⁴⁶ The EU advantage is especially evident in industrial-scale heat pumps, where integration with process heat and district heating networks requires advanced engineering and system design capabilities. These segments build on Europe's established expertise in thermodynamics, materials and system integration, giving EU manufacturers a technological edge in high-efficiency, custom-designed applications.⁴⁷ The EU is also a global leader in hydronic systems, including air-to-water, ground-to-water and water-to-water heat pumps, which dominate in colder climates and align well with Europe's existing radiator and district heating infrastructure.⁴⁸ In these types of heat pumps, European suppliers often provide turnkey engineering and integration services, not only within the EU but also in export markets such as North America and Asia.⁴⁹ In these

segments, EU firms compete more on quality and system performance than on price. This positioning reflects Europe's broader industrial strengths in high-end manufacturing and engineering-intensive clean technologies.

BOX 4. THE PRODUCTION STAGES WHERE THE EU IS MOST ACTIVE.

After sourcing key materials such as copper and aluminium, the first production stage involves the manufacture of individual components, including compressors, HEUs (evaporators and condensers), expansion valves, pumps, fans, electronic controls and refrigerants. Many of these components are manufactured by firms that also serve the broader heating, ventilation and air conditioning (HVAC) and refrigeration industries.

The second stage of the value chain involves assembly, design and system integration. This is where most EU-based heat pump producers are concentrated. Companies at this stage assemble both domestically produced and imported components into finished units, perform testing and certification to comply with EU energy-efficiency standards and to adapt product designs to different building and climatic conditions. Design and R&D activities also take place here, focusing on improving system performance, adapting to new refrigerants and integrating digital controls or storage systems.⁵⁰

Distribution, installation and maintenance – the downstream part of the value chain – are also of critical importance.⁵¹

These activities are typically labour-intensive and need to be carried out close to the end customer, as customisation is needed at times.⁵² For these reasons, national distributors, installers and service companies typically carry out these activities, as they are difficult to outsource.⁵³ Given the labour intensity of these activities, they generate a significant share of employment and will require more (skilled) workers if future adoption speeds up. With the rise of digitalisation, after-sales activities increasingly involve remote monitoring, predictive maintenance and data-driven performance optimisation.⁵⁴

Source: wiiw.

Major European producers include Bosch Thermotechnology, Vaillant, Viessmann, Stiebel Eltron, NIBE, Ariston, Daikin Europe and Glen Dimplex. Many of these firms have evolved from traditional boiler or HVAC manufacturers and now focus heavily on air-to-water and ground-source systems. Their long engineering heritage and established installer networks continue to underpin Europe's strong position in the global market.⁵⁵ Indeed, the European heat pump industry is characterised by relatively few firms that are "pure" heat pump producers.⁵⁶ Most companies operate across multiple adjacent sectors, such as HVAC, refrigeration and boilers, with heat pumps integrated into their broader product portfolios. This structure makes heat pumps strategically important but not necessarily dominant in many firms' activities. Alongside large companies, many SMEs supply components such as HEUs, buffer vessels and housings to larger manufacturers. This diversity ensures competition and supports innovation but also limits economies of scale. In contrast, China's

industry is dominated by a smaller number of very large players with vertically integrated supply chains, enabling them to capture cost efficiencies that European firms often struggle to achieve.⁵⁷

Across the EU, 265 production facilities are dedicated to heat pumps, spread over 21 member states (MSs), according to the European Heat Pump Association. If the list is extended to the European Economic Area and EU candidate countries, the number grows to 282. Italy and France are home to the largest numbers, followed by Germany, Spain and Poland.⁵⁸ These facilities tend to specialise in hydronic systems, which require local engineering expertise and integration capabilities.

Heat pump production in the EU has expanded steadily, reflecting growing demand driven by climate policy, energy security concerns and consumer interest in efficiency. Production has grown in both units and value, with the EU producing more than €5 billion worth of heat pumps in 2023, a significant increase from previous years.⁵⁹ These production expansions occurred in countries such as Poland, which has become a critical assembly hub, as well as capacity increases in Germany, France and Italy. However, these expansions occurred against a backdrop of demand volatility. While 2022 saw record sales due to the energy crisis, the market slowed in 2023, creating stress for firms that had invested heavily.

Looking ahead to future capacity expansions, Central European countries will benefit disproportionately, with a "heat pump valley" emerging in the area along the borders of Poland, Slovakia and Czechia. Indeed, it is estimated that almost half of planned investments in new capacity will take place in that area.⁶⁰

The literature provides only limited information on Europe's production capacities for individual heat pump components. No systematic assessment exists of where component manufacturing is located within the EU or how production capacities have evolved over time across the main elements of the heat pump value chain.⁶¹ Nevertheless, available evidence allows for a broad overview of the EU's

position across the main components of the heat pump value chain.

Overall, heat pump component manufacturing is a global operation. More standardised parts, such as fans, are mass-produced, while specialised components (most notably compressors and refrigerants) are produced by a smaller group of manufacturers.⁶² In particular:

1. **Compressors:** despite limited manufacturing levels in Europe, the main players are Danfoss (Denmark), Bitzer (Germany), Tecumseh (France), Copeland (US company with EU subsidiaries) and Dorin (Italy).⁶³ In addition, a few specialised firms in Italy and Germany manufacture industrial or niche compressors, but their global market share remains limited.⁶⁴ Some EU heat pump producers also manufacture compressors in-house. Trade and production data also suggest that EU companies have shifted their focus to higher-value segments (large-capacity or high-efficiency units used in industrial and commercial applications).⁶⁵ Most materials needed to produce compressors (most notably, steel, aluminium, copper, plastics and rubbers) are produced in the EU, but specialised materials (i.e., rare earth elements and specific alloys) are imported.⁶⁶
2. **HEUs:** Europe boasts a relatively strong production capacity, and a substantial base of SMEs and specialised firms manufacture HEUs within the EU. Most production is concentrated in Germany, Italy, France, Poland and Czechia, where companies such as SWEP, CAREL, Kelvion, Güntner, Alfa Laval, Danfoss and LU-VE Group play leading roles, at least as far as the EU is concerned.⁶⁷ Many of these firms also supply other industries, such as the refrigeration and automotive industries. The market has grown steadily in recent years, driven by increasing demand for efficient heating and cooling systems.
3. **Fans, pumps and ancillary components:** the EU has a relatively strong base in

these components, with many produced domestically. In the EU, fans are mainly manufactured by Ziehl-Abegg and ebm-papst (both German companies), while pumps are produced by Wilo (Germany) and Grundfos (Denmark).⁶⁸

4. **Refrigerants:** the EU has a significant but changing refrigerant industry, as it is phasing out high-GWP fluorinated gases in line with the EU F-gas Regulation and shifting toward natural refrigerants such as propane (R290), CO₂ (R744) and ammonia (R717). Major European chemical producers include Arkema (France), Linde Group (Germany) and Solvay (Belgium),⁶⁹ while GEA (Germany) leads ammonia development for heat pump use.

3.2 The trade performance and strategic dependencies of European heat pumps

Europe's trade position in heat pumps has undergone significant changes over the past decade. Until around 2020, the EU maintained a trade surplus, supported by strong domestic production of hydronic systems and exports to neighbouring non-EU markets such as the UK, Switzerland and Norway. Imports were relatively limited, as most of the European market was supplied by manufacturers within the Union.⁷⁰

From 2020 onwards, this balance began to deteriorate as imports rose sharply, particularly from China. Although European exports continued to grow, notably to nearby markets such as the UK, Switzerland and Norway, as well as in niche industrial applications, this growth was insufficient to offset the surge in imports. Between 2017 and 2021, the EU's previously positive trade balance became negative, driven by rising imports of compressors, electronics and low-cost complete units.⁷¹ By 2022, imports consistently outpaced exports, and the overall trade deficit in heat pumps exceeded €850 million, representing more than half of total extra-EU imports of €1.4 billion that year.⁷² This deterioration reflects the rapid expansion of imports of complete units from China, especially air-to-air heat pumps,

which already accounted for around 40% of EU sales in 2021,⁷³ turning the EU from a net exporter into a net importer over the past three years.⁷⁴

Globally, China dominates mass-market production (particularly in air-to-air heat pumps) and is rapidly expanding its hydronic systems capacity, underpinned by high domestic demand, lower labour costs and extensive state-supported investment. Japan remains a technological leader in compressors and inverter technology, supplying many European manufacturers. The USA, despite a large and fast-growing domestic market, focuses primarily on air-to-air systems and relies heavily on imports for components and hydronic units.⁷⁵

Within the EU, Germany is the EU's largest exporter of heat pumps, with strong export growth from 2015 to 2022. Its competitiveness is slightly above China's and significantly above the USA's.⁷⁶ Sweden is another important global player. Finland is a competitive exporter of reversible heat pumps.⁷⁷ Croatia exports reversible heat pumps, but remains far from being internationally competitive.

In terms of their components, the design and manufacture of compressors are specialised activities, so these have become dominated by a limited number of global suppliers.⁷⁸ Europe produces only a small share of the compressors it uses; around 90% of compressors in European heat pumps are imported.⁷⁹ Indeed, most compressors for EU heat pumps are designed in Asia or the USA but manufactured in (and therefore imported from) China, followed by Japan and South Korea.⁸⁰ The largest producers include Panasonic, Mitsubishi Electric and Highly Group.⁸¹ Meanwhile, the relatively low level of market concentration in the international market for this component suggests that no single country dominates the global export market for compressors, thus indicating a potential window of opportunity for expanding production in the EU.⁸²

HEUs are the EU's major strength, but EU producers face increasing competition, particularly from Asia. The characteristics of HEUs align well with Europe's tradition in mechanical and materials engineering, making them a strategically important component.

Nevertheless, high labour and energy costs in Europe, compared with those in Asia, remain a significant competitive challenge. These factors could erode cost advantages unless compensated for by continued innovation, quality differentiation and closer integration with adjacent industrial sectors.⁸³ Similarly to compressors, the international HEU market is characterised by low export concentration, indicating that entry opportunities still exist.⁸⁴

The supply of traditional refrigerants is dominated by China (by companies such as Dongyue and Sinochem), followed by the USA, where major players include Chemours (with a subsidiary in Switzerland), DowDuPont and Honeywell. Other major players are Asahi Glass (Japan), Daikin (Japan), SRF (India) and Koura (Mexico).⁸⁵ This situation could evolve in the future with the transition towards natural refrigerants in the EU (see Section 3.4.).

Table 2 summarises the competitive position of the most relevant EU MSs for some of the core components of a heat pump.

Table 2. A summary of the competitive position of MSs at the component level.

Component	EU MS performance
Compressors	DE: competitive, with significant RCA between 2017 and 2022 PT: strong, significantly outperforming China and the USA, with fast growth between 2017 and 2022
HEUs	FI: competitive and growing, but less competitive than the USA HU: RCA higher than China and the USA RO: competitive SE: higher RCA than China and the USA SI: RCA on par with China and the USA SK: improved competitiveness, outperforming China and the USA by 2022
Thermostats and controllers	BG: strong performance – RCA in 2022 higher than the USA and China; growth since 2015 FI: competitive and growing, but less competitive than the USA HR: some exporting capacity RO: competitive, with rapid growth from 2017 to 2022 and higher RCA than China and the USA⁸⁶

Note: RCA: revealed comparative advantage.

Source: wiiw, based on Directorate-General for Energy and ECORYS (2024).

Along its entire value chain, the EU heat pump industry exhibits the following strategic dependencies:

1. **Raw materials such as copper, steel and aluminium**, all of which are in global demand.⁸⁷ Volatile international prices for metals further affect competitiveness and the security of supply.⁸⁸ These vulnerabilities are not negligible. For example, air-to-air heat pumps for residential applications contain around 15-20 kg of copper, predominantly in their pipes and valves, making up roughly 10% of the overall cost of a heat pump, whereas residential hydronic heat pumps typically contain more than twice as much aluminium and 15 times more copper and brass than their condensing gas boiler equivalents.⁸⁹
2. **Rare earths:** permanent magnets used in compressor motors require rare earths, such as neodymium and dysprosium, for which Europe depends almost entirely on Chinese supply. For permanent magnets, the EU faces a supply risk.
3. **Control systems, sensors and circuit boards** are mainly assembled in the EU but rely heavily on imported semiconductors and electronic components from East Asia. This dependence exposes EU manufacturers to supply disruptions and price volatility in global electronics markets.⁹⁰ Considering the market size (especially compared to larger markets such as the automotive market), heat pump producers are the last to be served by chip producers.⁹¹

3.3 The technological competitiveness of the EU

Europe retains significant technological advantages in air-water and ground-water heat pumps, as well as industrial and large-scale heat pumps, especially those operating above 160°C. In particular, industrial and large-scale heat pumps are highly engineered systems for which EU firms have accumulated decades of know-how in process integration and district heating applications. Yet, this industrial segment is still small compared to residential demand: in 2019, only 19,000 heat pumps were installed in industry compared to 20 million in residential buildings in 2022.⁹²

As far as components are concerned, the EU is a technology leader in the use of natural refrigerants, a low-carbon, high-performance alternative to conventional systems that rely on HFCs. Natural refrigerants are considered a key opportunity for the future of the heat pump industry in the EU.⁹³ Indeed, natural refrigerants will further contribute to the environmental sustainability of this industry. This is also considered a lever for the EU's future competitiveness, enabling producers to identify niches in the global market.⁹⁴ More than 310 air-to-water heat pump models use natural refrigerants such as propane (R290) and CO₂ (R744). These models are already available in France, Italy, Spain, Portugal, Austria, Switzerland and Luxembourg and are produced by at least 48 different manufacturers. These models meet or exceed A++ energy efficiency ratings.⁹⁵ EU firms that move early may secure a first-mover advantage, but only if they can scale rapidly.

Europe is an important global contributor to R&D&I. Since 2013, MSs have spent about €118 million on public R&D&I into heat pumps.⁹⁶ The highest investment occurred between 2019 and 2021. From 2013 to 2023, the highest shares of spending were in Austria (31%), Denmark (27%), France (19%) and the Netherlands (13%).⁹⁷ China accounts for a much lower share of global R&D spending on heat pumps (8%), reflecting its current role as a mass producer of standardised components and lower-tech small heat pumps.⁹⁸ In terms of private R&D spending on heat pumps, Germany leads, followed by France,

Italy and Sweden. At the global level, it is estimated that in 2020, China led in private R&D investment, followed by Europe, Japan and the USA. The top EU investors (throughout the entire HVAC industry segment) were all German companies – Robert Bosch, Miele and Bosch Siemens Hausgeräte – plus one Swedish company, namely, E.ON Sverige.⁹⁹

Europe is also a key innovator, as proxied by the number of high-quality patents (i.e., patents filed at more than one patent office). From 2015 until 2020, the EU was the single most important patent filer for heat pump technologies, followed at a distance by Japan and the Republic of Korea. Exceptional growth was also recorded between 2016 and 2019. At the country level, between 2019 and 2021, Germany led in high-level patenting activities, followed by China, Japan and the USA. Among EU countries, France, Sweden, the Netherlands and Italy, were also among the global top ten.¹⁰⁰ Looking at the most active patent applicants, Vaillant (Germany) and LG (Korea) led high-value patenting activities, followed by Mitsubishi (Japan) and Qingdao (China). Moreover, at the firm level, five of the world's top ten patent applicants (i.e., Viessman Werke, E.ON Sverige, Hgforsgst, Bosch and X Therma) are headquartered in the EU.¹⁰¹

Europe files a large share of patents related to hydronic and industrial heat pumps. China, however, is catching up rapidly in R&D spending and patent applications, particularly in mass-market technologies.¹⁰² The USA has traditionally lagged behind in deployment but has recently increased its investments, especially under the Inflation Reduction Act, which provided significant subsidies for domestic production.

3.4 Other challenges and opportunities of the EU heat pump industry

The rapid expansion of heat pumps across Europe presents both short-term constraints and longer-term opportunities for industrial development. The pace of deployment has accelerated in response to EU climate targets and national decarbonisation plans, yet several structural and market barriers

continue to progress slowly. According to Toleikyte et al.,¹⁰³ the challenge is partially one of overall capacity but more one of ensuring stable demand, sufficient skilled labour and reliable access to critical components. Regarding demand, one of the most persistent challenges is the high upfront cost of heat pump systems, which remains a significant hurdle for many consumers.¹⁰⁴ Such high costs discourage adoption by consumers, even if heat pumps are a more cost-effective solution and offer long-term energy savings. Moreover, as Europe uses hydronic heat pumps (rather than air-based ones, as in the rest of the world), the market is naturally constrained by the EU's market size.¹⁰⁵

Energy cost structures also play a critical role. In several MSs, electricity is taxed more heavily than gas, reducing the operating-cost advantage of heat pumps and limiting their attractiveness for both households and industry.¹⁰⁶ In high-temperature industrial applications, fossil fuels often remain cheaper alternatives, although ongoing policy and innovation efforts are gradually closing this gap.¹⁰⁷

Beyond cost factors, the industry faces other challenges. The shortage of skilled installers and maintenance professionals, as well as regional differences in building stock and infrastructure readiness, constrain large-scale deployment. Diverging national standards for products and electrical grids add further complexity and discourage investment in new capacity.¹⁰⁸ Regulatory uncertainty also remains a concern.¹⁰⁹

At the same time, the transition results in important opportunities. The shift toward natural refrigerants such as propane, CO₂ and ammonia could reinforce Europe's technical leadership in sustainable refrigerant technologies.¹¹⁰ The growing electrification of district heating networks and industrial processes also broadens the market for large-scale and high-temperature heat pumps; areas where EU firms already have advanced technical capacity. Continued investment in research, development and demonstration – supported by Horizon Europe, the EU Innovation Fund, and national programmes – offers prospects for further

efficiency improvements, digital integration and cost reductions.¹¹¹

In the longer term, regulatory clarity, innovation and market growth could help stabilise the business environment and accelerate the decarbonisation of heating and cooling. The challenge for policymakers and industry alike is to convert these opportunities into a sustainable expansion path for domestic production that balances affordability, reliability and environmental ambition.

3.5 Summary

The key findings of this section can be summarised as follows:

1. The EU remains a significant global player in heat pumps and produces several of its key components.
2. The EU's competitive advantage lies in complex, high-quality segments rather than in low-cost mass production.
3. While the EU as a whole has shifted from a net exporter to a net importer of heat pumps in recent years, several MSs continue to demonstrate strong international positioning for specific components. Germany emerges as the production leader within the EU across a variety of components, while Central European countries are emerging as new production locations.
4. The EU also remains an important global contributor to global R&D&I, with Austria, Germany, Denmark, France, the Netherlands, Italy and Sweden being the largest spenders.
5. When proxied by the number of patents in heat pump technologies, the EU has been and remains a key innovator. Countries like Germany, France, Sweden, the Netherlands and Italy are particularly active, although China, Japan and South Korea are also key players.

4. METHODOLOGY

Building on the literature review from Section 3, the study now provides an in-depth examination of the five main components of a heat pump: compressors; HEUs; fans; controllers; and refrigerants (for the exact definition of the products covered, see Annex I). As the discussion has shown so far, various recent reports have analysed the heat pump industry, focusing on recent trends in production levels and trade, and qualitatively described the areas for future technological development.¹¹² Given that component manufacturing is at the core of current industrial policy discussions (as noted by Volt et al.¹¹³), a solid analysis of the EU's performance in terms of components is paramount to complement existing assessments and inform the current policy debate.

In particular, this study aims to determine **which components the EU should target from a strategic perspective and which ones can be feasibly produced within the EU**. To tackle this question, our analysis focuses on four critical dimensions: (1) production levels; (2) international competitiveness; (3) trade balances and import dependencies; and (4) innovation capacities. Table 3 details the type of assessment, lists the quantitative indicators, and outlines the analysis focus and data sources. Our choices are motivated by the factors explained below.

Because our study focuses on individual components, **we restrict our analysis to highly disaggregated data**. These data enable us to evaluate each component separately. However, this methodological decision limits the data sources available and, consequently, the breadth of the conclusions we can draw. For example, while it would be interesting and relevant to assess the number of jobs generated for each component in the EU (or lost in the event of fierce competition), this information is not available at the level of individual components.¹¹⁴ Similar considerations apply to R&D

data, which, if available, would allow us to assess the innovation efforts of EU MSs.

Data limitations also arise when we aim to benchmark EU production levels against those of other economies. On one hand, benchmarking is essential to any discussion of competitiveness. After all, competitiveness is a relative concept. On the other hand, highly disaggregated production data comparable across economies worldwide are not readily available.¹¹⁵ Because production levels are difficult to capture at the global level, we use a competitiveness index (the Balassa index, as explained in Box 5) and export unit prices as proxies for competitiveness.

When interpreting the quantitative results, it is also important to bear in mind that all components are used in other value chains beyond heat pumps, and statistical codes do not distinguish between final uses (e.g., between a HEU used in heat pumps and one used in data centres).¹¹⁶ For example, while official statistics include a product code for compressors, they do not distinguish between compressors for heat pumps, fridges or air conditioning. This means that we cannot say, for example, that the compressors analysed in this study are only those used for a heat pump. Given this versatility, the suggestions in this study may also be relevant to other products and industries that utilise the same components.

Acknowledging the aforementioned data limitations, **our methodology integrates quantitative data with qualitative assessments**. Insights from data analysis are complemented by qualitative considerations drawn from the literature reviews in Sections 2 and 3, nine semi-structured interviews with experts and industry stakeholders (for a list of interviewees, see Annex VI), company reports, and news.

Table 3. The type of assessment, indicators and data sources used in this study.

Dimension	Indicator	Focus of the analysis	Type of assessment	Source
Production levels	Value of products sold in 2023 and growth rates 2017-2023	EU MSs	Quantitative	Prodcom
	Assessment of whether EU production is significant and could be expanded	Global	Qualitative	Interviews
International competitiveness	RCA in 2017-2022 (levels and growth rate)	EU MSs + USA, China and Japan	Quantitative	BACI
	Export unit values			
Trade balances and import dependencies	Size of trade balance in 2023 and trend since 2017	EU	Quantitative	BACI
	Degree of concentration of EU imports from third parties	EU	Quantitative	BACI
	Assessment of whether the component constitutes a strategic dependency for the EU	EU	Qualitative	Interviews
Innovation capacities	Assessment of the nature of innovation	Global	Qualitative	Literature review and interviews
	Assessment of whether the component has innovation potential and the EU innovation capacities are significant compared to global leaders			

Source: wiiw.

**BOX 5. THE BALASSA INDEX
OF REVEALED COMPARATIVE
ADVANTAGE: A TECHNICAL
EXPLANATION.**

The Balassa index of RCA is a standard measure of international competitiveness. By using a country's export structure in comparison with global export structures, or a country's world market share in a product compared to the world market share in the country's overall exports, we can calculate the RCA of the country in that specific product. The RCA is above one when the share of that product within the country's export basket is larger than the share of the product in global markets. In this case, the country is said to have a comparative advantage in that product or is internationally competitive in exporting that product.

The index is computed as follows:

$$RCA_{ij} = \frac{X_{ij}/X_i}{X_{wj}/X_w}$$

where X_{ij} is the export value of product j from country i , X_i is the total export of country i , X_{wj} is the world export of product j and X_w is the total world export.

Source: wiiw.

5. ANALYSIS ACROSS THE HEAT PUMP COMPONENTS

This section presents an analysis of the five key components of the EU heat pump value chain. As explained in Section 4, it proceeds in four steps. First, production levels across EU MSs are examined using Prodcom data to identify the main producers and emerging manufacturing hubs. Second, trade patterns are analysed to assess the international position and competitiveness of EU producers. Third, import data are analysed to detect strategic dependencies that might undermine the EU's resilience and call for greater open strategic autonomy. Four, a qualitative overview of innovation trends is presented and the EU's relative position across the most innovative components is discussed.

5.1 Production levels

This section analyses the production levels of EU MSs for the main heat pump components, using Eurostat's Prodcom database (see Box 6 for data considerations regarding Prodcom).

BOX 6. DATA CONSIDERATIONS REGARDING PRODCOM DATA.

Prodcom data are subject to several limitations that must be taken into account when interpreting the results. First, some product categories contain missing observations for individual years. In cases where one or two years are missing but recent observations are available, linear interpolation has been used to reconstruct the time series. Second, discrepancies exist between the value reported for the EU27 aggregate and the sum of individual MSs. These differences mainly arise from

confidentiality restrictions and incomplete national reporting. Consequently, two approaches are used, depending on the figure's purpose. When analysing overall EU trends, the official EU27 aggregate reported in Prodcom is used. When calculating MS shares in EU production, the EU total is defined as the sum of available national values to ensure internal consistency. Third, geographical coverage is particularly limited for some refrigerant categories. In particular, the Prodcom category for refrigerant gas mixtures has very sparse national reporting and is therefore excluded from the country-level analysis. Finally, it is important to bear in mind that the majority of components analysed here are used in multiple products, but official statistics do not distinguish between different end uses of the same component. This ultimately means that the numbers presented here are to be taken as approximations of the production levels of the heat pump components, with actual figures for heat pumps being smaller.

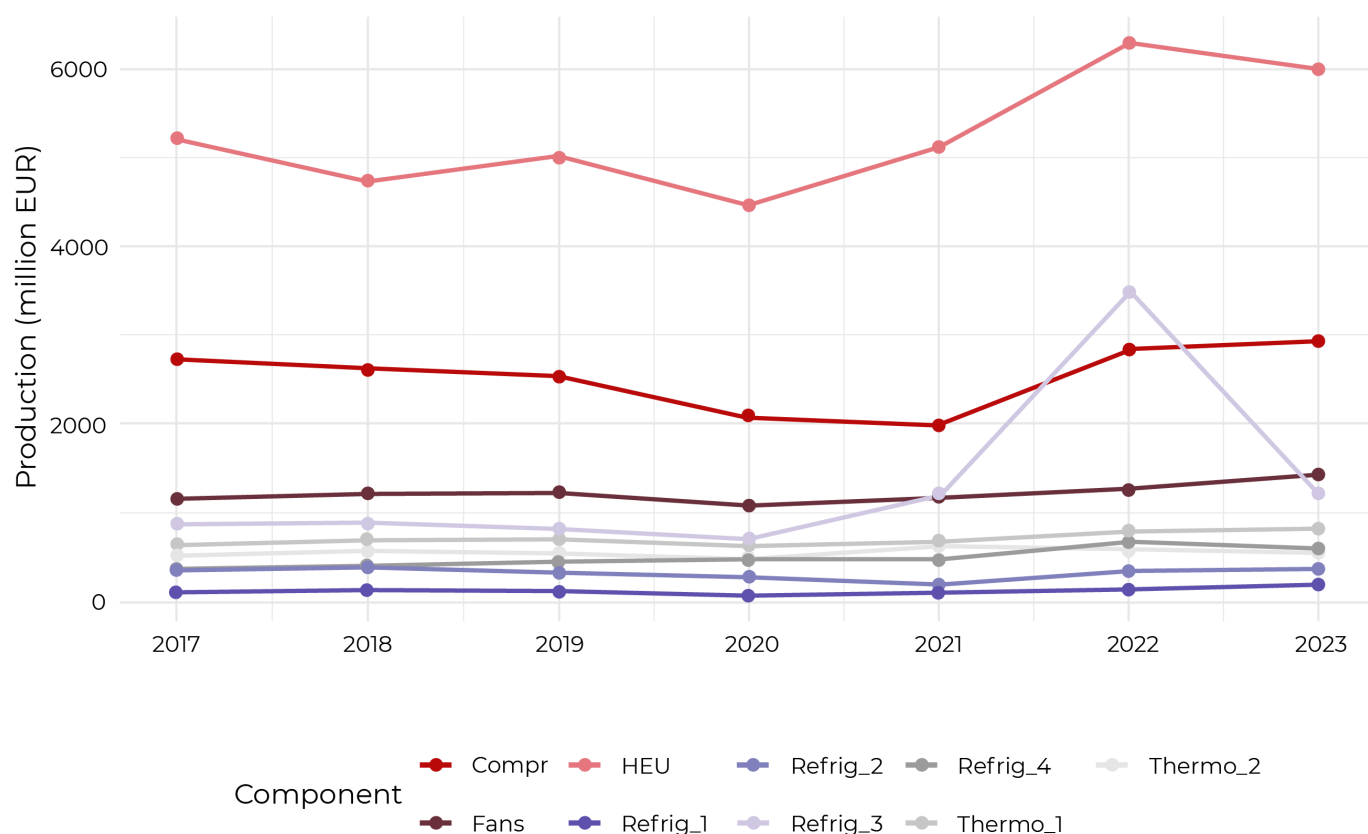
Table 11 in Annex I reports the correspondence between the component names used in the text and figures and their associated Prodcom and HS codes. Table 12 in Annex II provides a detailed assessment of the data quality of Prodcom data for each product code analysed in this study.

Source: wiiw.

EU production trends

To provide an initial overview of the scale of production across the heat pump value chain, Figure 2 reports the production value¹¹⁷ of the analysed components between 2017 and 2023.

Figure 2. EU27 heat pump component production value, 2017-2023.



Note: Compr: compressors; Thermo_1: thermostats; Thermo_2: other controllers; Refrig_1: mixtures; Refrig_2: HFC-32; Refrig_3: carbon dioxide; Refrig_4: ammonia.

Source: Prodcorn database, wiiw calculation.

A clear hierarchy emerges across mechanical components, with higher production values for HEUs and compressors. HEUs and compressors account for the highest production values in the EU, also reflecting their higher prices compared to other components. The next group consists of fans, thermostats and other controllers. These components are relatively more standardised than

compressors and HEUs (although they require customisation, particularly in the industrial market segment). Their production values are, therefore, lower, although still substantial, given their broad use in HVAC and other electrical equipment.

HEUs clearly dominate in production volumes, thanks to a strong production capacity in the EU. In

particular, roughly two thirds of heat exchangers and 50% of evaporators are made in the EU. EU producers are considered market leaders, particularly in brazed-plate heat exchangers, a compact, pressure-resistant variant of the HEU. Moreover, while European HEUs tend to be roughly 20% more expensive than their Chinese counterparts, the quality difference keeps EU products competitive in the global market.¹¹⁸

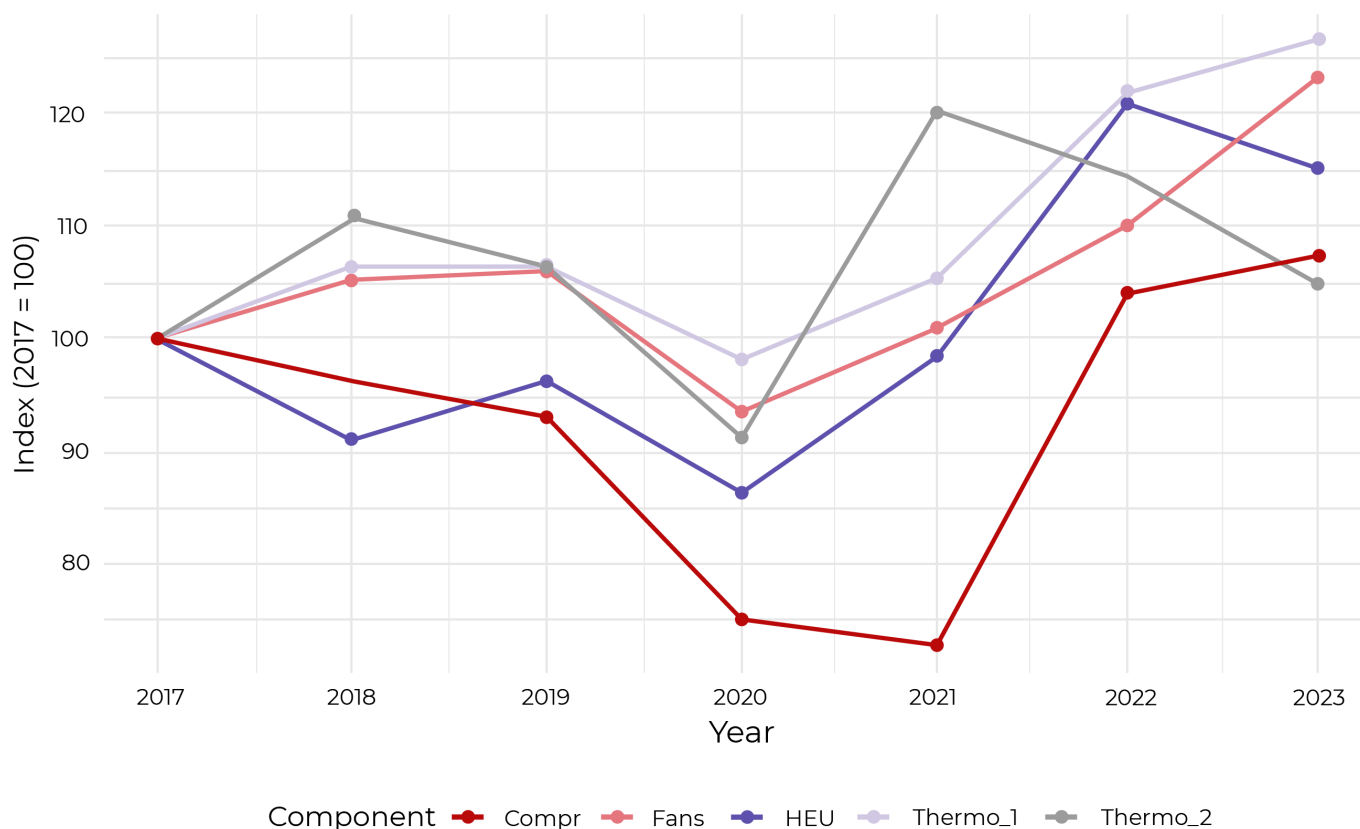
Regarding compressors, EU companies mostly assemble compressors for commercial systems (i.e., scroll compressors) rather than for residential ones (i.e., rotary compressors).¹¹⁹ In the scroll segment, some EU-based companies (e.g., the EU subsidiary of Copeland, as well as Danfoss) still operate in Europe, for example, via a few large factories in France. Scroll compressors produced in the EU (e.g., for Danfoss in France) are the larger variants, made for larger units and commanding high prices on the market. By contrast, light commercial scroll compressors are mostly produced and assembled in China, with intellectual property (IP) and designs usually not from Europe (albeit some EU companies, such as Danfoss, also own designs). Indeed, some EU companies do own the IP for scroll compressors: this is a significant advantage, given that these are the most high-end, larger variants of compressors. However, the switch to natural refrigerants would require moving from split systems to monoblocs (therefore, moving from scroll to rotary compressors), a change that raises safety concerns as well as deepening dependencies.¹²⁰ Indeed, as a largely commoditised product, rotary compressors are manufactured entirely in Asia (most notably China, but also Thailand and Japan), with Japanese-origin design and IP. Producing them in the EU would likely be uncompetitive (due to high EU production costs). **According to stakeholders, sustained and significant policy support would be needed to bring compressor production back to the EU.** If this were the case, manufacturers might add production lines to existing factories (even in higher-labour-cost locations) rather than opening new factories in lower-cost manufacturing hubs.

Refrigerants rank at the lower end of the ranking by production value. Within this group, CO₂ and ammonia exhibit the highest production levels.

Both gases are widely used in multiple industrial applications and therefore have a much broader market than the heat pump industry alone. By contrast, the production values of refrigerant gas mixtures and HFC-32 are substantially lower. These gases are used almost exclusively in heating and cooling applications, and their production volumes are further constrained by the ongoing regulatory phase-out of fluorinated gases in the EU.

It is important to understand that the subcomponents of the five components are mostly manufactured in Asia (mostly China) and imported. Therefore, and as confirmed by several stakeholders, the assembly of components is the main activity carried out in the EU. Often, the same EU company has opened subsidiaries in lower-cost locations in Asia to manufacture certain standardised components and subcomponents. The localisation of assembly activities in the EU is mainly due to the industry's predominant strategy: assemble locally for local markets (i.e., components needed for the EU market are assembled in the EU, and so are Asian or US components). Such a strategy, however, makes less sense for smaller components, such as scroll compressors for the residential market, which are, therefore, usually manufactured and assembled in China (with significant advantages). By contrast, for bulky items, most notably HEUs, larger weights would not justify shipping the final products from far away.¹²¹ **Figure 3 illustrates the production dynamics more clearly by presenting EU27 production trends in value terms for compressors, HEUs, fans, thermostats and other controllers, indexed to 2017.** In the years preceding the COVID-19 pandemic, production dynamics differed substantially across components. Lower-value and more standardised components, such as thermostats and fans, recorded moderate growth of between 5% and 10% between 2017 and 2019. By contrast, higher-value components, particularly compressors and HEUs, followed a declining trajectory over the same period, with production falling by roughly 5%.

Figure 3. EU27 mechanical component production value, index 2017 = 100%.



Note: Compr: compressors; Thermo_1: thermostats; Thermo_2: other controllers.

Source: Prodcorn database, wiiw calculation.

The pandemic caused a sharp contraction across all components. Production dropped below 2017 levels in 2020, reflecting supply chain disruptions and reduced industrial activity. **Most components rebounded relatively quickly.** By 2021, the production of fans, thermostats and HEUs had recovered and surpassed their 2017 levels. Compressors followed a slightly slower trajectory but also rebounded strongly, exceeding their pre-pandemic benchmark by 2022. By 2023, thermostats and fans showed the strongest growth relative to 2017, expanding by roughly 25%. HEUs also grew, though more modestly, reaching approximately 15% above their 2017 level (see Box 7). Compressor production increased by only around 8% over the same period. As other controllers began to decline after 2021, their overall growth over the period was only around 5%.

While these increases are positive, they appear more moderate when compared with the broader expansion of the European heat pump sector during the same years. Toleikyte et al. point to a 30% increase in the value of EU heat pump production in 2023 compared to the previous year (see Box 7).¹²² Against this backdrop, the growth observed for most upstream components in this analysis suggests steady expansion, though not at the pace seen in the downstream heat pump market. Moreover, the asymmetry in production dynamics across components is economically meaningful. **Growth has been strongest in relatively standardised components such as fans and thermostats, while the more technologically complex component, compressors, expanded only modestly.**

BOX 7. QUALITATIVE EVIDENCE ON RECENT PRODUCTION TRENDS FOR TWO COMPONENTS: HEUS AND FANS.

Fans

Before the pandemic, fan supply chains were based in Asia, with Thailand as the assembly hub. Delivery time was 104 weeks (i.e., 2 years). During the pandemic, fans were classified as a strategically important industry and were therefore permitted to continue operating during lockdowns across EU countries, as well as in Thailand. This is because fans are essential components of cleanroom systems. After the pandemic, fan production expanded into Europe, specifically Germany and Poland. While this shift increased production costs and was enabled by policy support, it also offered faster delivery times and a lower carbon footprint. For example, today Vaillant operates factories in Poland, Czechia and Slovakia.

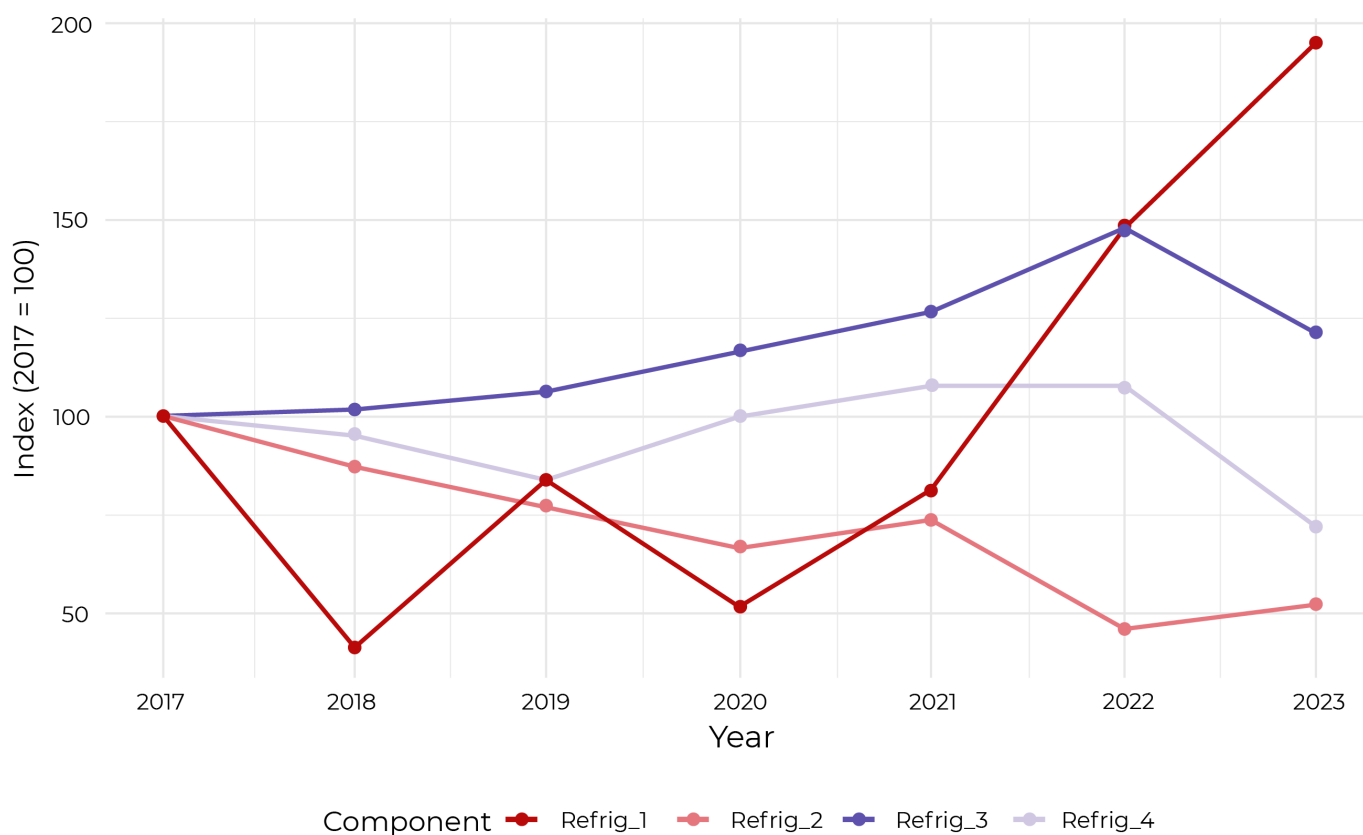
HEUs

In 2023, heat pump manufacturers benefited from a demand peak, created by a combination of factors (i.e., the energy price hike following Russia's aggression against Ukraine and subsidies in MSs incentivising the switch to heat pumps). Component manufacturers could not keep up with the surge in demand, thus creating additional demand for imported components (mainly from Asia). Heat pump manufacturers responded by stocking components. This strategy, coupled with the discontinuation of the subsidy schemes, depressed demand in 2024. Demand from data centres (another use market of HEUs) helped stabilise demand in more recent years.

Source: wiiw, based on interviews.

Figure 4 reports **production trends for refrigerants using quantities rather than values due to substantial price volatility in some gases, particularly CO₂ and ammonia**. The pre-pandemic period shows declines in most refrigerants, except CO₂. Production of refrigerant gas mixtures initially declined and fluctuated before recovering in 2022. From that point onwards, production increased rapidly and by 2023 exceeded its 2017 level by roughly 50%. By contrast, the production of HFC-32 followed an almost continuous downward trajectory throughout the period, declining by approximately 50% by 2023. This trend likely reflects the gradual phase-out of fluorinated gases mandated by EU environmental regulations.

Figure 4. EU27 refrigerant production quantity, index 2017 = 100%.



Notes: Refrig_1: mixtures; Refrig_2: HFC-32; Refrig_3: CO₂; Refrig_4: ammonia.

Source: Prodcom database, wiiw calculation.

CO₂ displayed the most stable expansion path. Production increased steadily from 2017 onwards and remained resilient even during the pandemic. Although production declined slightly in 2023, it still grew by around 25% over the period. Ammonia production remained broadly stable for several years before experiencing a sharp contraction toward the end of the period. As a result, production declined by approximately 25% by 2023. These patterns reflect the regulatory and technological transition underway in refrigerant markets. The decline in synthetic fluorinated gases is consistent with the EU F-gas Regulation, while the gradual expansion of natural refrigerants, such as CO₂, signals a shift toward lower-global-warming-potential alternatives. **This transition is likely to reshape the competitive landscape of refrigerant production, favouring firms capable of adapting production processes**

and safety standards to the new generation of refrigerants.

Production levels and trends in EU MSs

Figure 5 presents the five largest producers for each component, measured as their average share of EU production between 2017 and 2023. As discussed previously, these shares are calculated relative to the sum of available national production values. Results can be summarised as follows:

1. **Compressors:**¹²³ Germany clearly dominates EU production, accounting for roughly 30% of total output. France also ranks among the largest producers, accounting for approximately 12% of production. For example, Danfoss still operates a large factory in France.

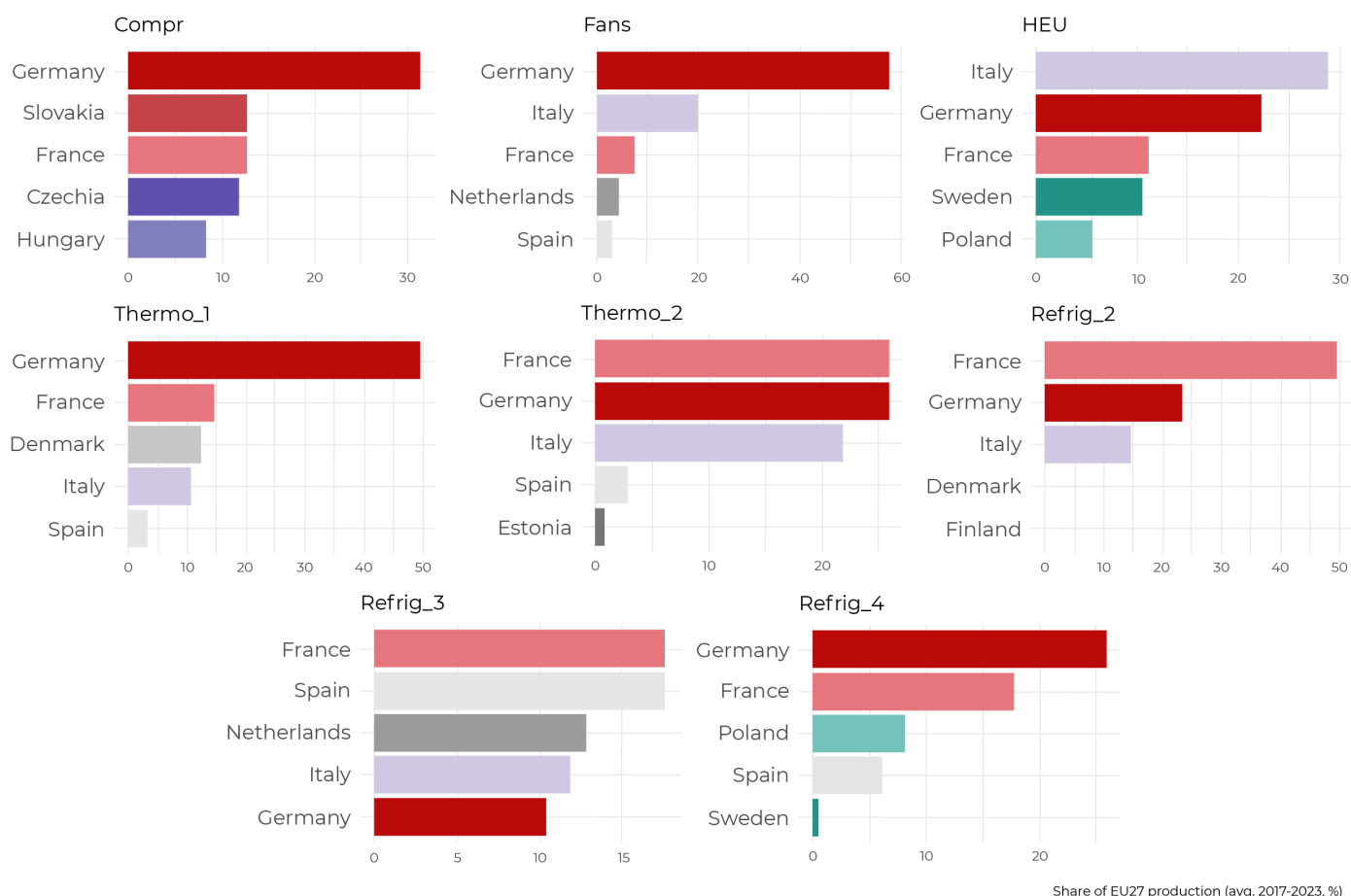
Interestingly, the remaining top producers are Central and Eastern European economies, namely, Slovakia, Czechia and Hungary.¹²⁴ The presence of these countries among the leading producers reflects the increasing integration of Central and Eastern European economies into European manufacturing value chains. Over the past two decades, these countries have attracted substantial foreign direct investment in machinery and HVAC-related industries, both from EU partners and East Asian countries. They have benefited from lower labour costs, proximity to Western European markets and strong industrial linkages with German manufacturers.

2. **HEU:** production capacities are more evenly distributed. Italy is the largest producer, accounting for slightly less than 30% of EU output, followed by Germany (22%). France and Sweden each contribute slightly above 10%, while Poland is the only Central and Eastern European country among the top five producers, with around 5% of total production.
3. **Fans:** a much more concentrated structure emerges, with Germany alone producing roughly 60% of EU output and Italy accounting for another 20%.¹²⁵ The remaining top producers, namely, France, the Netherlands and Spain, contribute significantly smaller shares.
4. **Thermostats** display a structure similar to that of fans, with Germany again dominating production at roughly 50% of the EU total in the case of electronic ones, while still being one of the main producers of other controllers at around 25%. In the case of the former, France, Denmark and Italy each account for between 10% and 15%, while Spain completes the top five with a share below 5%. With regards to other controllers, France is on par with Germany, while Italy is a close third, with Spain being in the top five in this case as well.
5. **Refrigerants:** production patterns vary considerably across gases. HFC-32 production

is highly concentrated, with France producing the majority of EU output and Germany and Italy accounting for most of the remainder. CO₂ and ammonia are less specific to heat pump technologies and, therefore, exhibit a more diversified production structure. For CO₂, France and Spain are the leading producers, each accounting for approximately 17.5% of EU output. The Netherlands, Italy and Germany follow with shares slightly above 10%. The largest producer of ammonia is Germany, accounting for roughly 20% of EU production. France is another significant producer in the EU.

Overall, the production of components is concentrated in larger Western European economies (e.g. Germany, Italy and France) but several Central and Eastern European countries (e.g. Slovakia, Czechia, Hungary and Poland) play an important role in specific segments of the value chain, particularly thanks to their labour cost advantages compared to Western European economies. According to interviews, production in countries such as Germany, the Netherlands or Ireland would only be profitable with high levels of automation. Germany, in particular, suffers from skill shortages. In this respect, automation is expected to play a significant role in the industry's future innovation efforts.

Figure 5. Top five MSs in terms of production value by component (average share of EU27 production 2017-2023).



Note: Compr: compressors; Thermo_1: thermostats; Thermo_2: other controllers; Refrig_2: HFC-32; Refrig_3: carbon dioxide; Refrig_4: ammonia. Refrig_1 is not included in the figure due to poor data coverage.

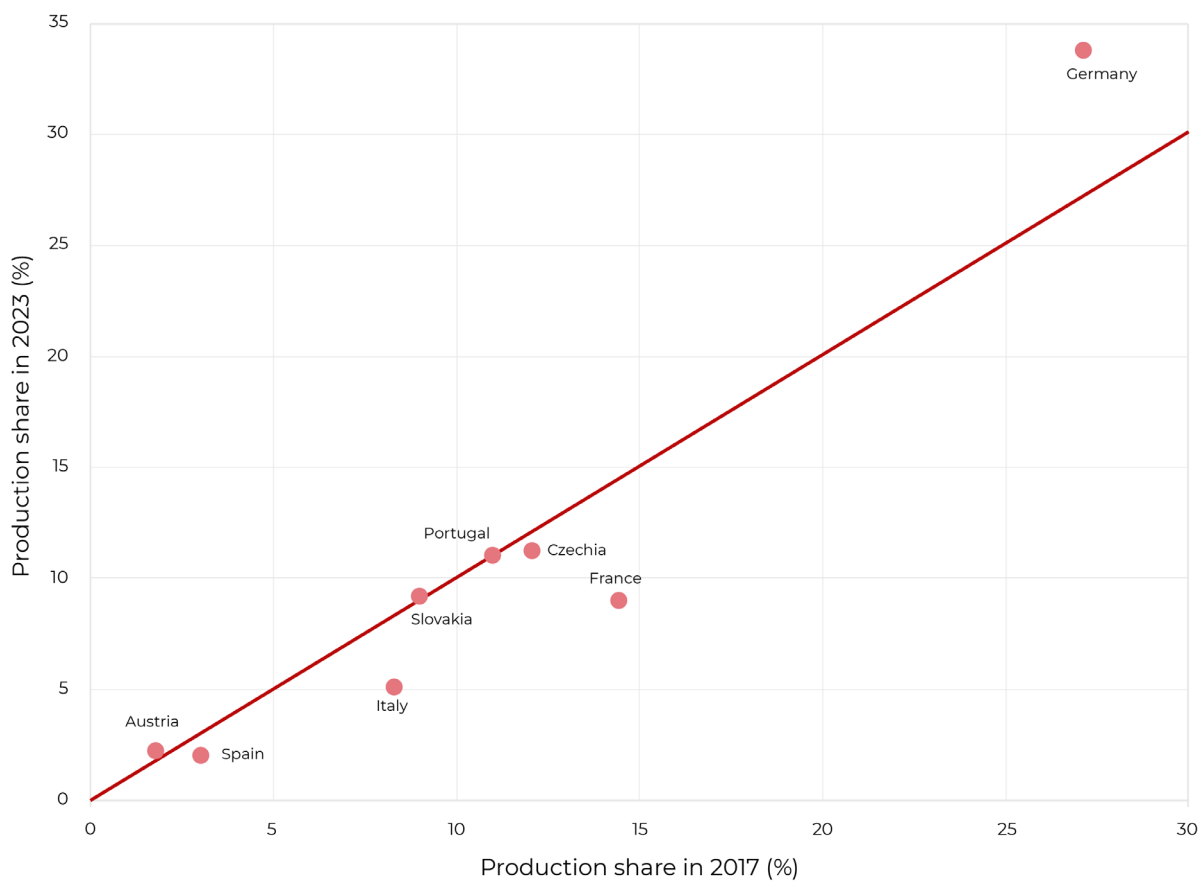
Source: Prodcorn database, wiiw calculation.

Changes in the structure of EU production

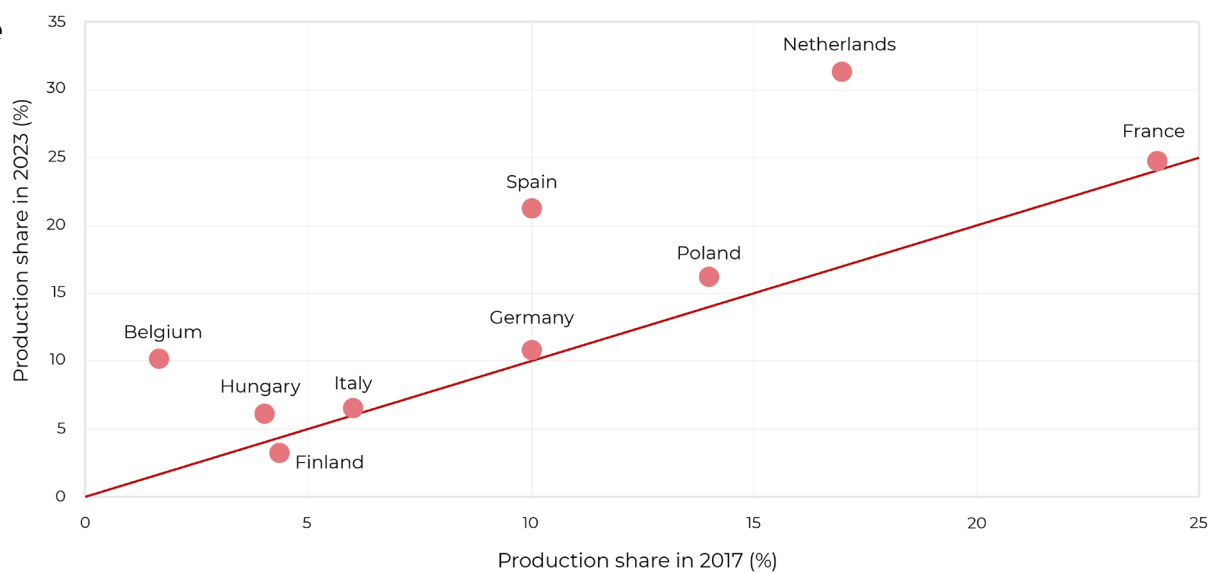
Figure 6 compares MS shares of EU production in 2017 and 2023 for the two components that display the most significant dynamics: compressors and CO₂. The diagonal line in each graph represents unchanged production shares. Countries above the line increased their share of EU production during the period, while countries below the line experienced a decline.

Figure 6. EU production share of compressors and CO2 by MS for 2017 versus 2023.

Compressors



Carbon dioxide



Source: Prodcom database, wiiw calculation.

- For **compressors**, the overall production structure remained largely unchanged. Germany continued to dominate EU production and maintained a broadly similar share over the period. Slovakia – another relevant producer – also remained close to its initial position. Still, a few countries (most notably Czechia, France and Italy) experienced clear declines in their share of EU production.
- For **CO₂**, the changes in production shares are more pronounced. The Netherlands recorded the largest increase in its share of EU production. Spain and Belgium also achieved significant gains.

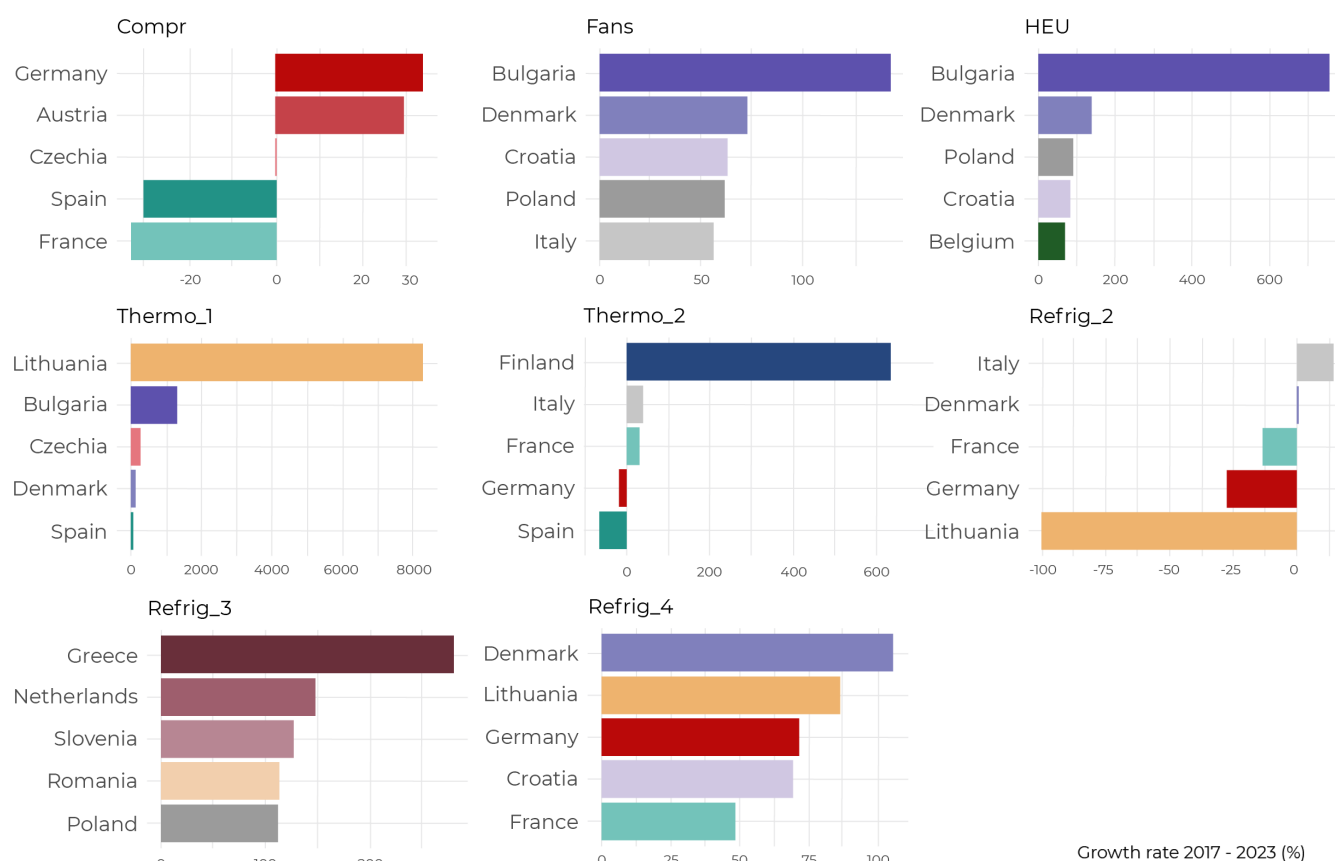
Taken together, data on changes in production structure reveal that the **geographical distribution**

of EU production has remained relatively stable across virtually all components, although some traditional players lost ground and new players (mostly from Central and Eastern Europe) emerged or consolidated their positions. Spurred by policy changes, somewhat greater adjustments are visible in CO₂, where several EU countries are expanding their production.

EU production trends: Growth rates

While production shares highlight the current industrial structure, growth rates provide insights into emerging production hubs. Figure 7 presents the five MSs with the highest production growth for each component between 2017 and 2023.

Figure 7. Top five MSs in terms of production value by component (growth rate 2017-2023).



Note: Compr: compressors; Thermo_1: thermostats; Thermo_2: other controllers; Refrig_2: HFC-32; Refrig_3: carbon dioxide; Refrig_4: ammonia. Refrig_1 was not included due to poor data coverage.

Source: Prodcorn database, wiiw calculation.

- For **compressors**, overall EU growth has been limited. Expansion is concentrated in only two countries, while another one is stagnating and the others are declining. Germany, already the largest producer, increased production by nearly 30%. Austria also recorded notable growth despite not yet being among the top producers.
- For **fans**, the strongest growth occurred in countries that are not currently the largest producers. Bulgaria recorded the most remarkable expansion, with production increasing by nearly 170%. Denmark, Croatia, Poland and Italy also recorded strong growth exceeding 50%.
- A similar pattern appears for **HEUs**. Bulgaria again stands out with production increasing more than sevenfold between 2017 and 2023. Denmark and Poland also recorded strong growth exceeding 100%, while Croatia and Belgium experienced increases above 50%.
- **Thermostats** reveal even more striking growth dynamics. Bulgaria again recorded very strong growth, with production increasing more than tenfold. Lithuania registered the most dramatic expansion with production increasing by more than 8,000%, although from a very low initial base. Czechia, Denmark and Spain also recorded strong increases.
- For **other controllers**, Finland stands out with an impressive growth rate of more than 600%, while the other two countries to achieve any growth are two major producers in Italy and France.
- For **refrigerants**, production dynamics differ across gases. For HFC-32, significant growth occurred only in Italy, while Denmark recorded modest expansion and production declined elsewhere. CO₂ production increased strongly in several smaller MSs, including Greece, Slovenia, Romania and Poland, with growth exceeding 100%. Among major producers, the Netherlands also experienced strong growth of approximately 150%. Ammonia production grew rapidly in Denmark and Lithuania, while Germany and France also experienced notable increases.

While several smaller MSs recorded extremely high growth rates, these increases often originate from a very small initial production base. Nevertheless, **such dynamics may signal the emergence of new production hubs within the EU, particularly in countries where investment in machinery, electronics and HVAC manufacturing has accelerated in recent years** (see the qualitative evidence gathered in Box 8).

BOX 8. QUALITATIVE EVIDENCE ON PRODUCTION EXPANSION IN THE EU.

According to interviews, company websites and news items, various companies indicate plans to expand production amid demand growth. For example:

1. Alfa Laval is among the companies with the largest EU production capacities in the area of HEUs. It is strengthening its manufacturing of **brazed-plate heat exchangers**¹²⁶ through extensive capacity expansion in factories in San Bonifacio (Italy) and Ronneby (Sweden). The investment also includes expansion into current sites in Italy, China and Sweden.
2. German **fan** specialist Ziehl-Abegg completed a new fan production line worth tens of millions of euros in Germany, specifically targeting the heat pump market.
3. In May 2024, US-based Copeland announced a €22.1 million investment in its **compressor** manufacturing facility in Cookstown, Northern Ireland (UK), which it said would increase production capacity to meet the growing European demand. The company also operates a factory in Czechia and one in Belgium.
4. Italian **controls** manufacturer Carel was planning two new factories in Europe and, in April 2024, opened a new

research centre at its headquarters in Padua, Italy.

5. In September 2025, Panasonic invested €320 million into the expansion of a heat pump factory with an R&D centre in Czechia (Pilsen). The factory is highly automated, and the plan is to achieve 100% automation in component manufacturing in the future.

Interviews support the view that **the EU retains a strong manufacturing base for several key heat pump components (most notably HEUs) and could expand production if market conditions warranted it.**¹²⁷ This applies to several components. For example, Alfa Laval's Slovakian factory could outcompete Chinese production if it could operate on a larger scale. This insight confirms the role of production volumes and demand stability for this industry. In addition, European manufacturers have expanded fan production facilities in recent years and continue to supply a large share of the European market. One interviewee noted that production had shifted towards Europe following supply chain disruptions during the COVID-19 pandemic, with facilities in Germany and Poland expanding production. Stakeholders also emphasised Europe's strengths in areas such as natural refrigerants, while noting that compressor production remains an area where European manufacturers remain dependent on suppliers outside the EU.

Overall, interviewees indicated that **EU manufacturers would have the technical capabilities and production capacity to scale up the output of key components**, but that further expansion would require significant investment and continued efforts to strengthen the resilience of upstream supply chains.

Source: wiiw, based on desk research and interviews.

The results in a nutshell:

1. The highest EU production levels are observed for HEUs and compressors.
2. The strongest growth was observed for thermostats and fans, while HEUs grew more modestly, and compressor production increased only marginally.
3. Production is concentrated in larger Western European economies (i.e., Germany, Italy and France).
4. Several Central and Eastern European countries (e.g., Slovakia, Czechia and Hungary) play an important role in specific components, particularly compressors.
5. For certain components (compressors, fans and thermostats), EU production is highly concentrated.
6. Production patterns vary considerably across refrigerants: HFC-32 production is highly concentrated, while CO₂ and ammonia exhibit a more diversified production structure.
7. Geographical distribution of EU production has remained relatively stable across virtually all components, although some traditional players lost ground and new players (mostly from Central and Eastern Europe) emerged or consolidated their positions.
8. Growth in production has been driven by a small number of countries rather than reflecting a broad-based expansion of manufacturing capacities.
9. While several smaller MSs recorded extremely high growth rates, these increases often originate from a very small base. Still, such dynamics may signal the emergence of new production hubs within the EU.

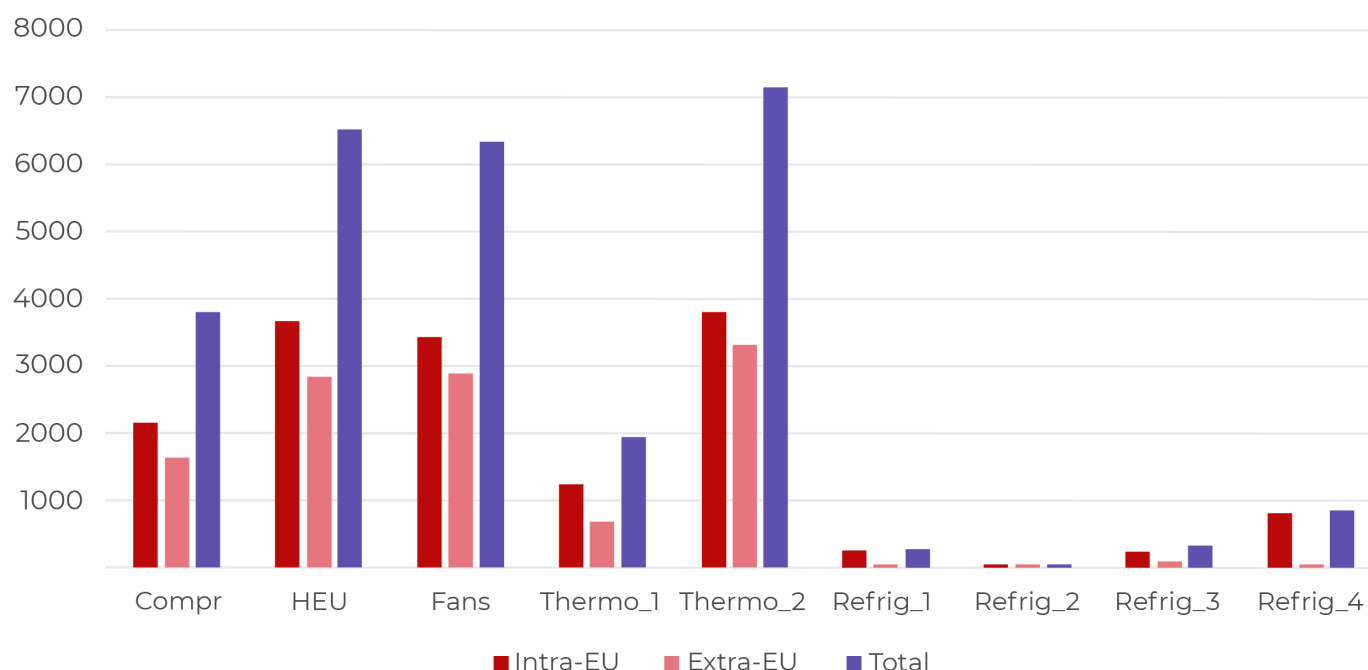
5.2 Export performance and international competitiveness

EU exports: Static and dynamic view

In 2023, EU exports of heat pump components were highly concentrated in a limited number of products, primarily controllers, followed by HEUs and fans (Figure 8). This concentration reflects the EU's comparative strength in relatively standardised and modular components, where production processes

are well established and less cost-sensitive than in more technologically complex segments such as compressors. Compressor exports were also relevant in absolute terms, while exports of refrigerant gases remained negligible. Intra-EU exports accounted for the largest share across all components, pointing to the strong integration of European value chains. At the same time, this also suggests that the EU's external competitiveness in global markets is more limited than aggregate export figures might imply.

Figure 8. EU exports of heat pump components, in million US dollars in 2023.



Note: Compr: compressors; Thermo_1: thermostats; Thermo_2: other controllers; Refrig_1: mixtures; Refrig_2: HFC-32; Refrig_3: carbon dioxide; Refrig_4: ammonia.

Source: BACI database, wiiw calculation.

Between 2017 and 2023, export dynamics were uneven across components. Total EU exports increased significantly only for CO₂ and ammonia, although in both cases export volumes remain negligible in absolute terms (Figure 9).¹²⁸ This indicates that recent growth reflects niche expansion rather than a broad-based strengthening of the EU's export position. Exports of HEUs, fans,

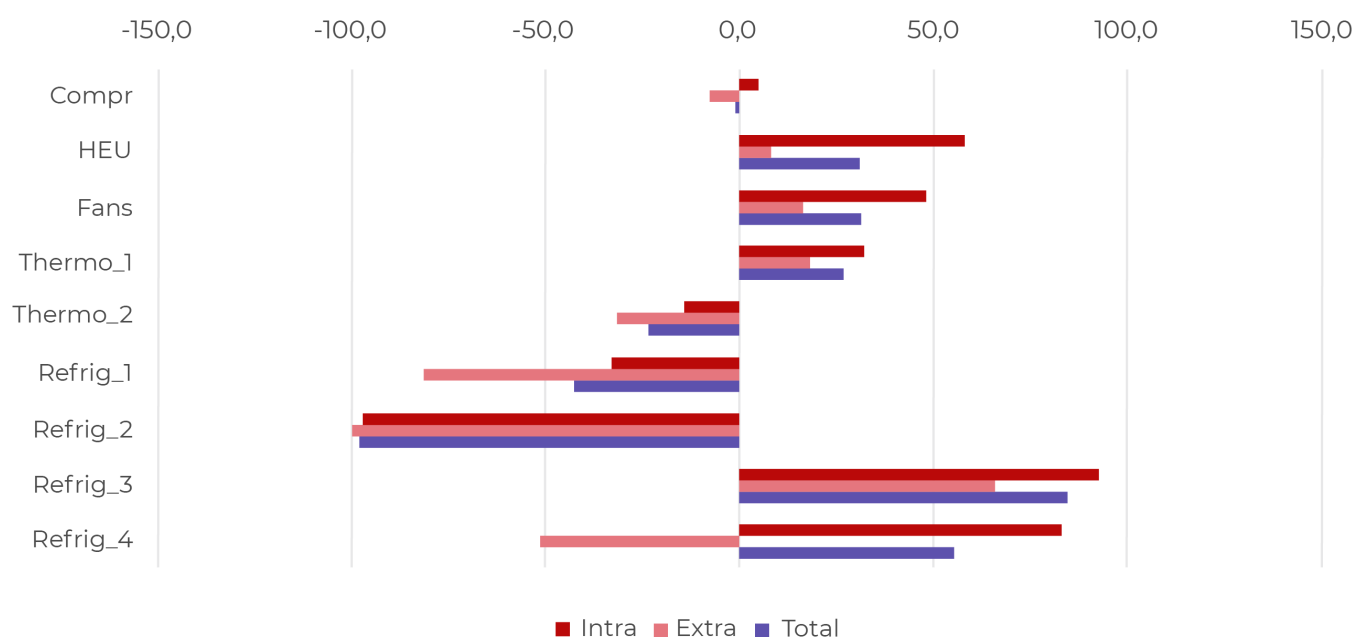
and thermostats grew by roughly 30%, broadly in line with the expansion of production capacities discussed earlier. By contrast, compressor exports remained largely stagnant, while exports of the remaining refrigerant categories declined, most notably HFC-32. Across all components, intra-EU exports either expanded more or contracted less

than extra-EU exports, **highlighting the importance of internal EU demand in sustaining production.**

Overall, the export structure closely mirrors the EU's production patterns, with stronger performance in

standardised components and weaker dynamics in technologically complex segments. This alignment suggests that existing production capabilities continue to shape the EU's position in international markets.

Figure 9. EU total exports of heat pump components, growth rates 2023 versus 2017, in %.



Note: Compr: compressors; Thermo_1: thermostats; Thermo_2: other controllers; Refrig_1: mixtures; Refrig_2: HFC-32; Refrig_3: carbon dioxide; Refrig_4: ammonia.

Source: BACI database, wiiw calculation.

Exports of EU MSs with respect to other global players

Figure 10 presents extra-EU export volumes by the EU and its most relevant MSs, broken down by component. The USA, China and Japan are also included to provide a comparison with EU players. **When comparing the EU with other major global players, a differentiated picture emerges across components.** China dominates exports of compressors and fans and has strengthened its position considerably since 2017. In compressors, the EU remained the second-largest exporter, although its exports declined slightly over the period. Japan nearly matches EU export volumes, while

China further widened its lead. In fans, the EU was a close second to China in 2017, but by 2023, the gap had increased substantially as Chinese exports expanded more rapidly.

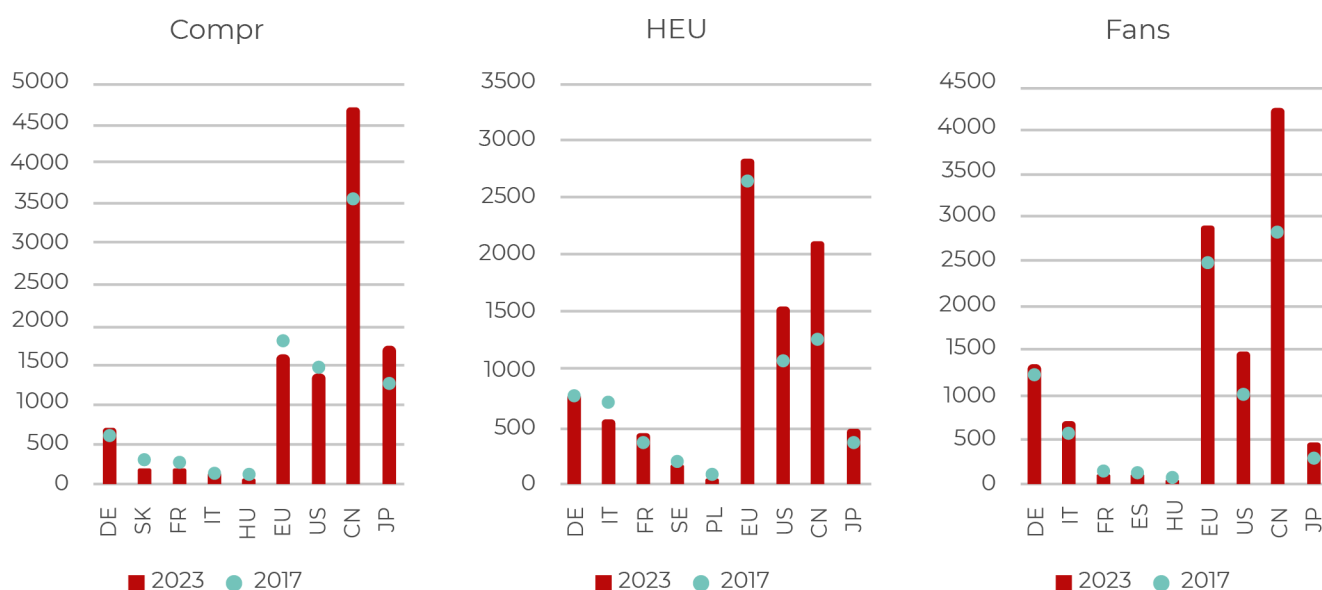
HEUs are the only components in which the EU maintained a clear global lead in 2023. Nevertheless, China has been catching up quickly, narrowing the gap over time. For thermostats, the EU retained a strong second position and remained relatively close to China. Notably, this was the only mechanical component for which Chinese exports declined, albeit only slightly, between 2017 and 2023. In controllers, the EU was comfortably the largest

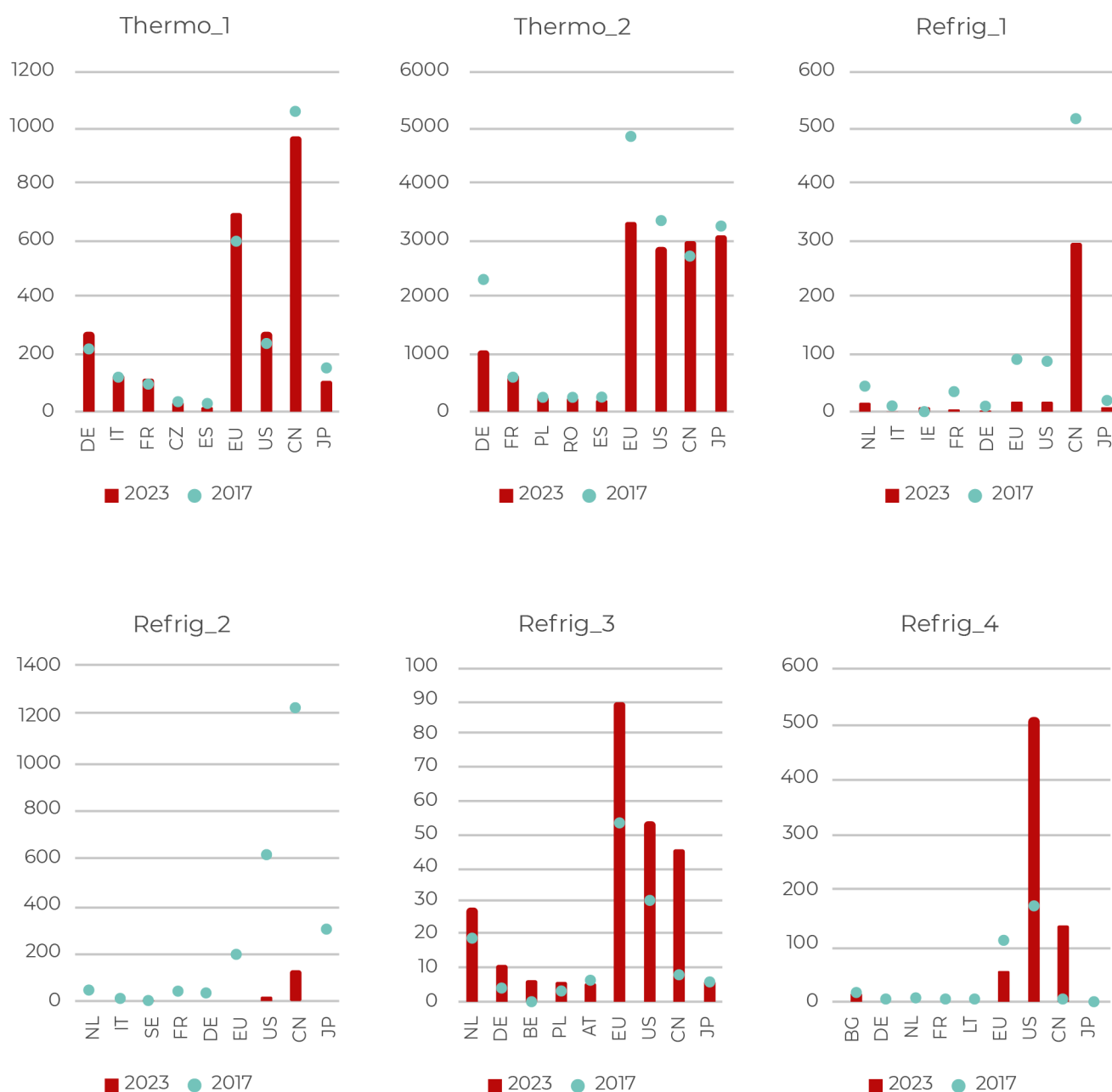
exporter in 2017, but its lead largely disappeared by 2023, with export volumes converging towards those of China, Japan and the USA.

The EU's position was generally weaker in refrigerants. The bloc lost ground relative to other major exporters across most refrigerant categories between 2017 and 2023, reflecting a broader decline in its global export position. While individual MSs remained important exporters of certain refrigerants, the EU no longer held a leading position in these markets. The USA remained the dominant exporter of CO₂ and ammonia, while China continued to strengthen its presence across several refrigerant categories.

Despite these broad trends, Germany remained the largest EU exporter for all mechanical and electronic components except refrigerants, with particularly strong export performance in controllers and fans. Italy and France also featured prominently, especially in HEUs and fans, while Sweden, Spain, and several Central and Eastern European countries – namely, Hungary, Poland, Slovakia, Czechia and Romania – ranked among the leading exporters across various components. For refrigerants, the Netherlands remained the leading EU exporter of all refrigerants except ammonia, for which Bulgaria recorded the highest export volumes, albeit at a very low level.

Figure 10. Top five EU MSs, the EU overall, US, China and Japan for various exports in 2017 and 2023, in millions of US dollars.





Note: Compr: compressors; Thermo_1: thermostats; Thermo_2: other controllers; Refrig_1: mixtures; Refrig_2: HFC-32; Refrig_3: CO₂; Refrig_4: ammonia.

Source: BACI database, wiiw calculation.

The scatter plots in Figure 11 compare the shares of individual EU MSs in extra-EU exports of selected components in 2017 (x axis) and 2023 (y axis). Components not illustrated here show strong stability in export shares. Points above the diagonal indicate countries that increased their export share over the period, while points below indicate a loss of share. By examining countries that did not emerge as top performers, the graphs help to highlight emerging hubs within the EU. To help appreciate these changes, we also take into account export growth rates (displayed in Table 15 of Annex IV). The main findings of these combined analyses can be summarised as follows:

1. **Compressors – high concentration and relative stability:** Germany dominates the picture by a wide margin, holding by far the largest share in both years, and its position above the diagonal signals a further consolidation of its leading role over the period. Slovakia and France form a second tier, with shares of 13-15% in both years. Italy occupies a middle position, with a share of around 8-9% in both years, and sits close to the diagonal, pointing to relative stability. The remaining MSs cluster in the lower-left corner of Figure 11, all holding shares below 5% in both years. Beyond these key players, performance is highly heterogeneous across EU MSs. Exceptionally high growth rates were recorded in Central and Eastern European countries (Bulgaria, Croatia and Estonia), as well as Sweden and the Netherlands (see Table 15 in Annex IV). While all start from low bases, their growth rates are higher than in China, the world's top compressor exporter. On one hand, high growth rates are mechanically easier to achieve when starting from a low base. On the other hand, such high growth rates might reflect genuine latent potential if they can be sustained over time.
2. **HEUs – high concentration among a few large exporters:** Germany consolidates its leadership, while France makes modest gains, and Italy experiences the most notable relative decline among the top players. Eastern

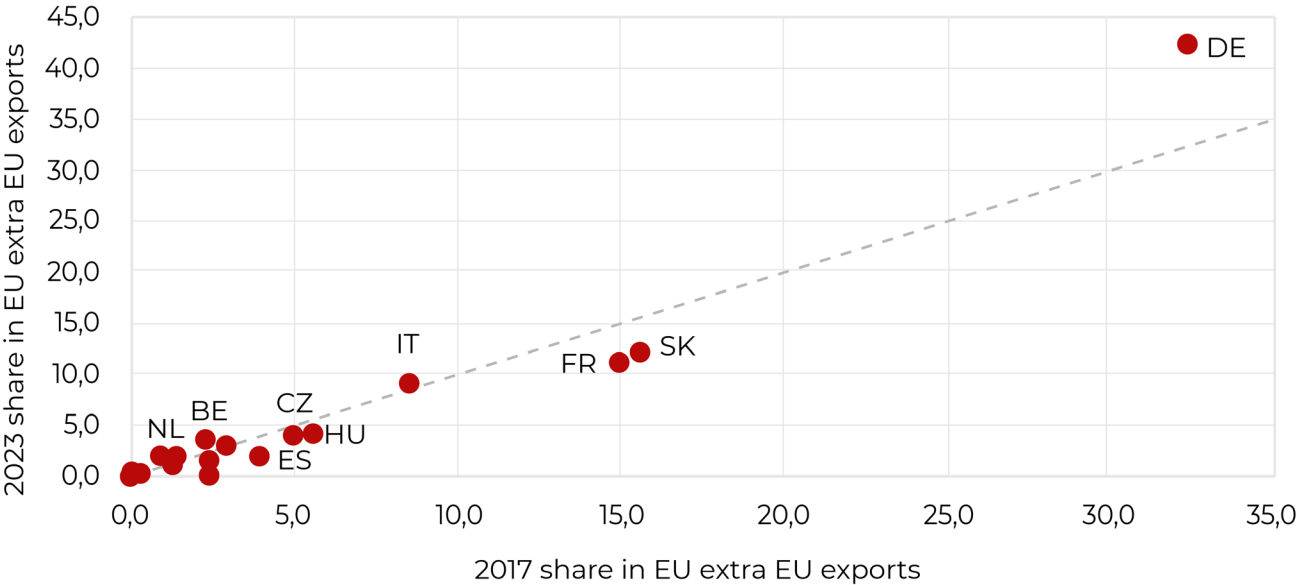
European countries, particularly Bulgaria and Romania (as well as Slovakia and Poland), show the fastest growth rates, consistent with the evidence reported in Section 2.4. In the EU, Bulgaria and Romania are the only countries growing faster than China (Table 15).

3. **Thermostats – moderately concentrated market with some reshuffling among mid-tier exporters:** Germany holds firm at the top, France emerges as a relative winner, while Italy and Denmark lose ground. As we have observed with the other components, Eastern European countries, particularly Romania, Poland and Czechia, are experiencing the fastest export growth rates. These growth rates are particularly welcome: Eastern European countries might be capturing markets, as Chinese exports shrank and US exports grew only mildly.

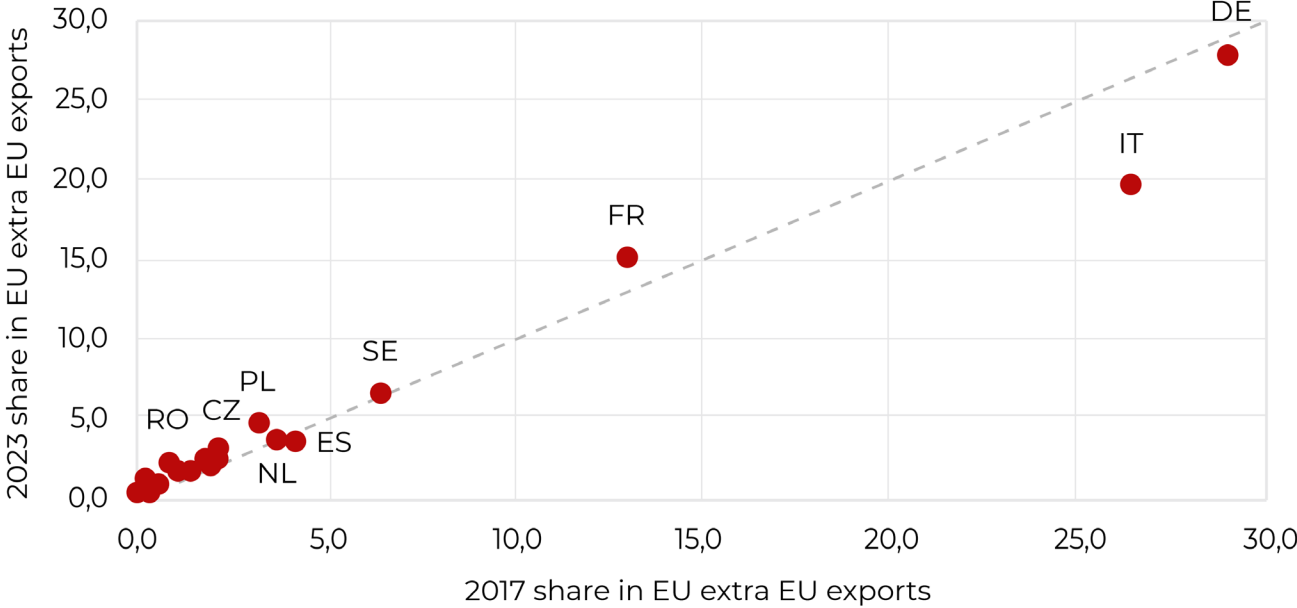
As for the other components, although overall positions remain unaffected, some EU countries are growing rapidly, possibly hinting at a strengthening of the EU value chain. These include Slovakia, Belgium and Ireland for fans, and Austria and Poland for other controllers. All these countries experienced faster export growth than China. Regarding refrigerants, unsurprisingly, exports of more traditional refrigerants (mixtures and HFC-32) declined across the EU. By contrast, exports of greener alternatives increased more widely. In particular, CO₂ exports increased rapidly in Belgium (the third-largest EU exporter), Bulgaria and Czechia. For all of them, the growth rate has been even higher than in China. For ammonia, export volumes are generally negligible, so any growth rates are from a very low base. Still, some countries stand out: Hungary and Poland, both growing more rapidly than China.

Figure 11. EU MS shares in total extra-EU exports, for 2017 and 2023, in %.

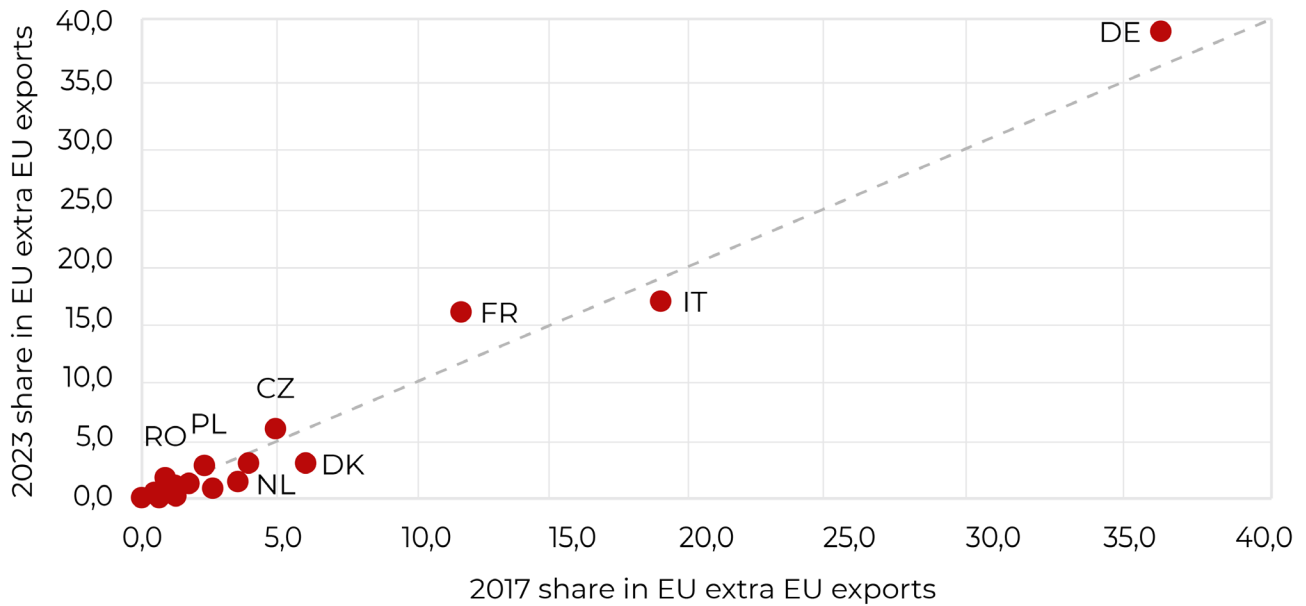
Compressors



HEU



Thermostats



Source: BACI database, wiiw calculation.

Table 4 summarises the main results regarding exporters and export dynamics.

Table 4. A summary of key results for export trends.

	Top global exporter	Top EU exporter	Fastest growth	Fastest growth in the EU
Compressors	China	DE	BG, EE, LU	BG, EE, LU
HEUs	China	DE	PT, LU, BG	PT, LU, BG
Fans	China	DE	CY, SK, BE	CY, SK, BE
Thermostats	China	DE	CY, RO, LV	CY, RO, LV
Other controllers	Japan	DE	LV, MT, EL	LV, MT, EL
Mixtures	China	NL	IE, SE	IE, SE
HCF-32	China	NL	IE	IE
CO2	USA	NL	LV, LU, BG	LV, LU, BG
Ammonia	USA	BG	HU, PL, CN	HU, PL, FR

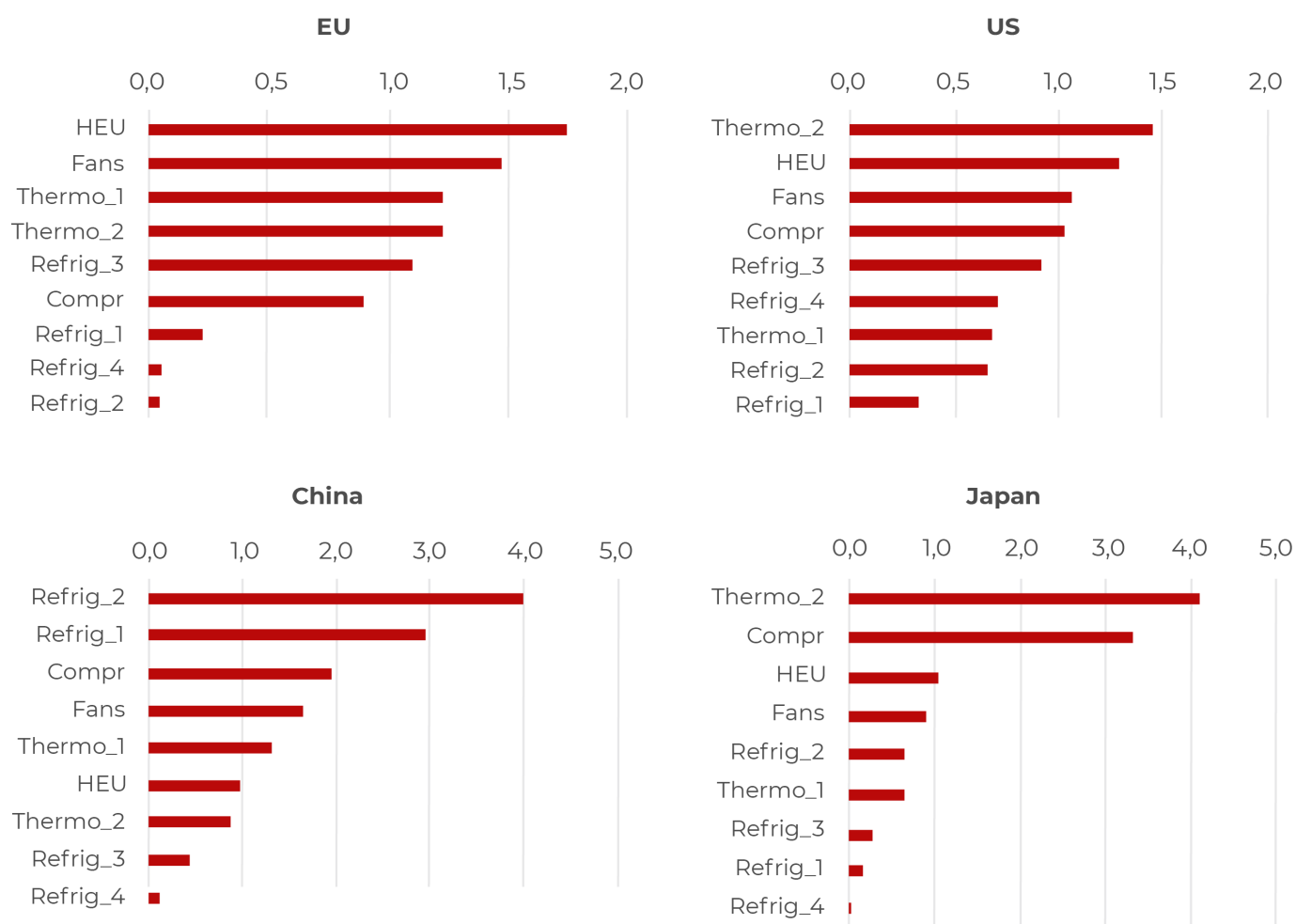
Source: wiiw.

The EU international competitiveness

To assess global competitiveness, the study uses a standard metric in international trade and competitiveness analyses, namely, the RCA index (see Box 5 for the exact definition). The RCA compares the share of a component in a country's total exports with the corresponding share of that component in global trade. An index value above one indicates that the component performs better than the global benchmark, and thus exhibits a comparative advantage, while a value below one signals the absence of such an advantage.

Figure 12 ranks the heat pump components by their RCA values for 2023. For the EU, **the following components recorded RCA indices above one: HEUs; fans; thermostats; and CO₂.** Among these, HEUs are the components with the largest positive difference compared with China, pointing to strong EU competitiveness. The USA is a competitive exporter of controllers, HEUs, fans and compressors. China is internationally competitive across most components, with the only exceptions being controllers, CO₂ and ammonia. Its RCA values are substantially higher than those of the EU and the USA. For Japan, three components recorded an RCA above one: controllers; compressors; and HEUs. Moreover, for controllers, the RCA values were substantially higher than those of the EU and the USA.

Figure 12. RCA index of the EU, USA, China and Japan in 2023.



Note: Compr: compressors; Thermo_1: thermostats; Thermo_2: other controllers; Refrig_1: mixtures; Refrig_2: HFC-32; Refrig_3: carbon dioxide; Refrig_4: ammonia.

Source: BACI database, wiiw calculation.

When examining the RCAs of the most relevant EU MSs (Table 5), two striking findings emerge: (1) **some EU MSs are competitive across a variety of components**; and (2) as before, **the competitive landscape for refrigerants is very peculiar, and the EU shows relative competitiveness only for CO₂**. Regarding the first finding, Hungary exhibits a comparative advantage for six of the nine heat pump components, with the highest advantage for other controllers (although still smaller than Japan's). Czechia and Germany are competitive for five

components, while Poland and Romania each show a comparative advantage for four components. This picture hints at a significant role of Central and Eastern European countries.

Table 16 in Annex IV details the RCAs of all EU MS against the EU average, and the RCAs of China, Japan, and the US. Looking at the components, the following competitive positions emerge:

1. **Compressors: Slovakia** emerges as the most competitive country, with an RCA more than double that of Japan. Four other MSs are also competitive globally (see Table 16 in Annex IV), with one of them (Hungary) proving more competitive than China.
2. **HEU: Sweden** exhibits the highest RCA in the world (thanks to the presence of HEU market leaders, namely, Alfa Laval and SWEP). Overall, 17 MSs are competitive at the global level, with 12 more competitive than the USA. This indicates that HEUs form a strong competitive basis in the EU.
3. **Fans: Italy** is the best performer, and six other EU MSs are internationally competitive. Three other countries (Germany, Hungary and Slovakia) show a strong competitive position, on par with or above that of other global competitors (China and the USA).
4. **Thermostats: Czechia** is the top performer in the world, followed at a distance by 11 other EU MSs. In most of these countries, RCA values are higher than in China.
5. **Other controllers: Romania** is the top performer, with an RCA higher than that of Japan (the world leader). Fourteen additional EU MSs are globally competitive (see Table 16 in Annex IV), with Hungary, Czechia and Poland having an RCA higher than or close to Japan's. Taken together, these results indicate a strong cluster for controllers in Central and Eastern European economies.
6. **Traditional refrigerants: the Netherlands** is the only competitive exporter of one traditional refrigerant (mixtures containing halogenated derivatives of methane, ethane or propane).

7. **Natural refrigerants:** for CO₂, ten MSs show an RCA greater than one, with **the Netherlands** emerging as the world's most competitive exporter. The Netherlands' leadership position, combined with widespread export capacities across the EU, suggests this could be a niche for future EU expansion. Among the EU's ammonia exporters, Bulgaria is the only competitive exporter within the EU.

Table 5. RCAs for selected EU MSs, the EU, the USA, China and Japan in 2023.

	Compr	HEU	Fans	Thermo_1	Thermo_2	Refrig_1	Refrig_2	Refrig_3	Refrig_4
AT	0.34	1.75	0.61	0.29	1.11	0.00	.	2.57	0.03
BE	0.29	0.82	0.48	0.10	0.65	0.02	0.00	1.70	0.03
BG	0.22	0.47	0.22	1.25	1.28	.	.	0.03	3.63
CZ	1.77	1.79	0.89	3.57	3.08	0.01	.	2.58	0.00
FR	0.92	2.42	0.65	1.79	1.53	0.12	0.03	0.56	0.03
DE	1.32	1.73	2.41	1.69	1.39	0.04	0.01	0.48	0.04
HU	2.33	1.92	2.81	1.03	3.75	.	.	3.03	0.00
IE	0.02	0.02	0.03	0.10	0.04	0.51	0.03	0.06	0.00
IT	0.66	2.87	3.03	1.75	0.48	0.25	0.03	0.21	0.00
LT	0.14	0.28	0.28	0.52	0.57	0.02	.	1.60	0.27
NL	0.24	0.86	0.48	0.27	0.57	1.95	0.33	5.02	0.13
PL	0.84	2.47	0.96	1.11	2.91	.	0.01	2.31	0.02
RO	0.17	2.62	1.29	1.69	6.34	.	.	0.35	0.00
SK	8.12	1.84	1.69	0.94	0.80	.	.	0.00	.
ES	0.29	0.98	1.00	0.64	1.06	0.01	0.01	1.03	0.01
SE	0.10	3.37	0.54	0.41	1.09	0.17	0.10	2.01	0.03
EU	0.89	1.74	1.48	1.23	1.23	0.23	0.04	1.10	0.06
US	1.03	1.30	1.07	0.69	1.46	0.34	0.67	0.93	0.71
China	1.96	1.00	1.66	1.31	0.84	2.96	4.00	0.43	0.10
Japan	3.33	1.06	0.91	0.65	4.10	0.17	0.65	0.30	0.00

Note: Compr: compressors; Thermo_1: thermostats; Thermo_2: other controllers; Refrig_1: mixtures; Refrig_2: HFC-32; Refrig_3: carbon dioxide; Refrig_4: ammonia. The figures are based on extra-EU exports. Cells coloured in green indicate that the country has an RCA in that component, while cells coloured in red indicate a comparative disadvantage. The table shows only the top five countries by RCA value and component.

Source: BACI database, wiiw calculation.

Figure 13 shows changes in RCA indexes from 2017 to 2023 (in percentage points) on the horizontal axis and RCA indexes in 2023 on the vertical axis. The two red lines separate four quadrants:

- countries in the top right quadrant show high and growing competitiveness;
- countries in the top left quadrant are internationally competitive countries whose competitiveness eroded over the period under analysis;
- countries in the lower left quadrant are lagging countries, that is, countries whose competitiveness is low and decreasing over the period 2017-2023; and

- countries in the lower right quadrant are newly emerging players, with low but increasing competitiveness.

The main takeaways of Figure 13 can be summarised as follows:

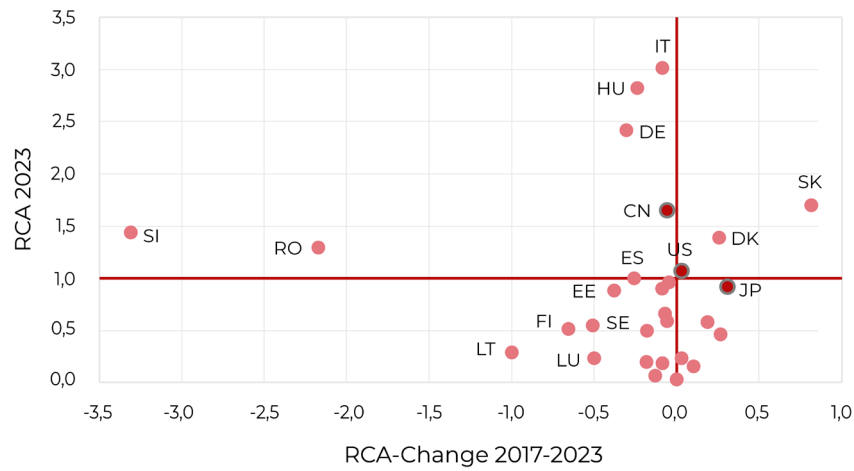
1. **Compressors:** a group of MSs (Portugal, Estonia and Germany) have a level of competitiveness on par with Japan and China, and their changes are also at similar levels. By contrast, Hungary and Czechia show high but decreasing RCAs. Slovakia (an outlier not depicted here) stands out for its very high but strongly eroding competitiveness.

2. **HEU**: several MSs show high but declining RCA: an erosion of comparative advantage across traditional European producers is accompanied by the rise of some Eastern European countries (most notably Poland).
3. **Fans**: most countries cluster near the origin with slightly declining RCAs, while a handful of EU MSs (Italy, Hungary and Germany) maintain strong specialisation, with Slovakia a notable outlier with a high RCA and significant improvement.
4. **Thermostats** show the most populated top right quadrant, pointing to a comparative advantage that is growing across multiple MSs, particularly in Central and Eastern Europe.
5. **Other controllers**: Central and Eastern European MSs (Czechia, Poland, Estonia, Romania and Latvia) are deepening their specialisations, while traditionally strong producers such as Hungary, Germany and Denmark are losing their comparative advantage.

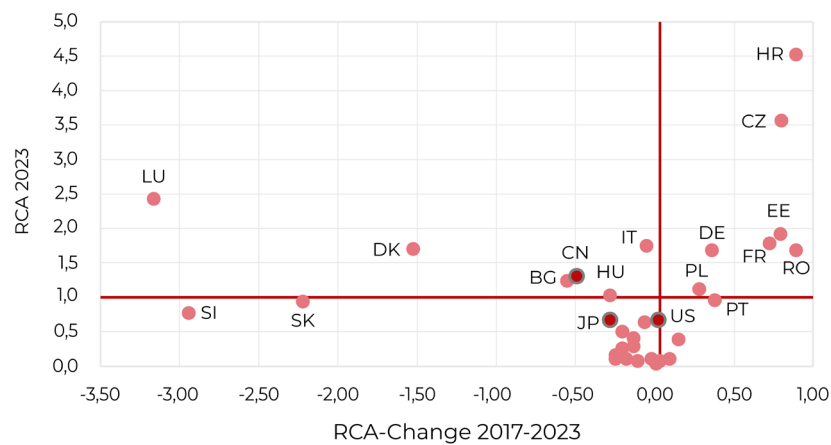
Figure 13. Comparison of RCAs in 2023 and RCA change (2017-2023) for selected components.



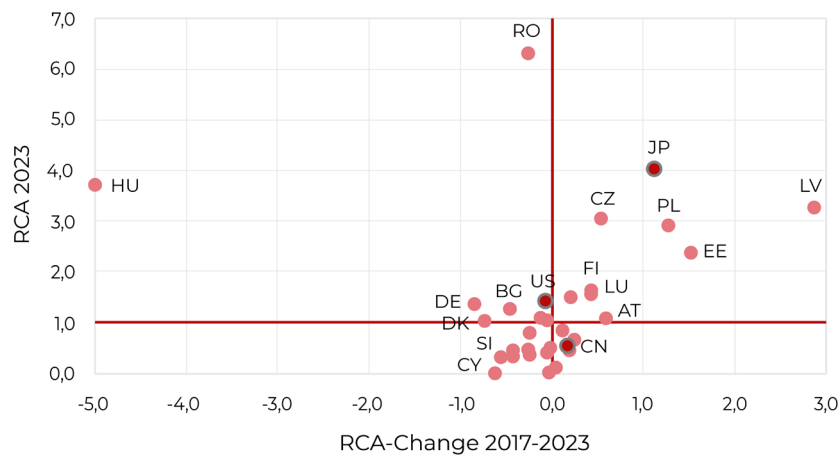
Fans



Thermostats



Other controllers



Source: BACI database, wiiw calculation.

Export quality as a competitive lever: Export prices and their trends

An examination of export unit values (calculated as total export value divided by total quantity) provides an indication of the average price per unit for the exported component and acts as a proxy for product quality (Table 6). A number of key findings emerge. First, the **highest export unit values are observed for other controllers, reflecting their technological complexity** (as explained in Section 2.2). By contrast, refrigerants have the lowest unit values, although prices are generally increasing, particularly for ammonia. This finding suggests that **ammonia could be an interesting market niche for the EU in the future**. Second, **EU export unit values are generally higher than those of China, which records the lowest prices, but are lower than those**

of the USA and Japan. This finding suggests that the USA and Japan may be offering higher-quality, higher-tech versions of these products, pointing to opportunities to improve the EU's competitiveness beyond quantity. Third, changes in export unit values between 2017 and 2023 (indicated in brackets in Table 6) indicate **broad-based quality upgrading across virtually all products for the EU and the USA**. Indeed, for the EU, export unit values declined only for HFC-32, reflecting recent policy changes. In Japan, decreases were observed across most components, with the most significant declines in fans, gas mixtures and ammonia. For China, declines were recorded for thermostats, other controllers and traditional refrigerants. For the other components, price increases suggest a strategic shift towards higher-quality production. Interviewees confirmed that China is entering the higher-end markets.

Table 6. Export unit values in 2023 and changes from 2017 to 2023 (in %, in brackets).

Component	EU	US	China	Japan
Compr	13.5 (40.4)	15.3 (26.3)	6.1 (9.7)	16.7 (7.7)
HEU	22.1 (30.2)	27.2 (40.2)	11.5 (25.6)	31.0 (41.4)
fans	23.7 (44.8)	26.8 (52.7)	14.2 (23.7)	33.7 (64.8)
Thermo_1	53.3 (19.9)	96.6 (57.2)	44.2 (-3.9)	50.1 (-8.7)
Thermo_2	108.2 (30.6)	177.8 (32.3)	57.7 (-17.2)	115.2 (15.9)
Refrig_1	12.5 (49.8)	14.8 (134.2)	3.3 (-26.3)	8.0 (-70.8)
Refrig_2	6.5 (-25.8)	7.5 (14.7)	2.5 (-51.7)	31.0 (66.3)
Refrig_3	0.2 (25.4)	0.3 (94.2)	0.4 (69.3)	7.0 (-32.0)
Refrig_4	0.7 (125.1)	0.5 (105.1)	0.7 (14.1)	8.9 (86.6)

Notes: Compr: compressors; Thermo_1: thermostats; Thermo_2: other controllers; Refrig_1: Mixtures; Refrig_2: HFC-32; Refrig_3: carbon dioxide; Refrig_4: ammonia.

Source: BACI database, wiiw calculation.

The results in a nutshell:

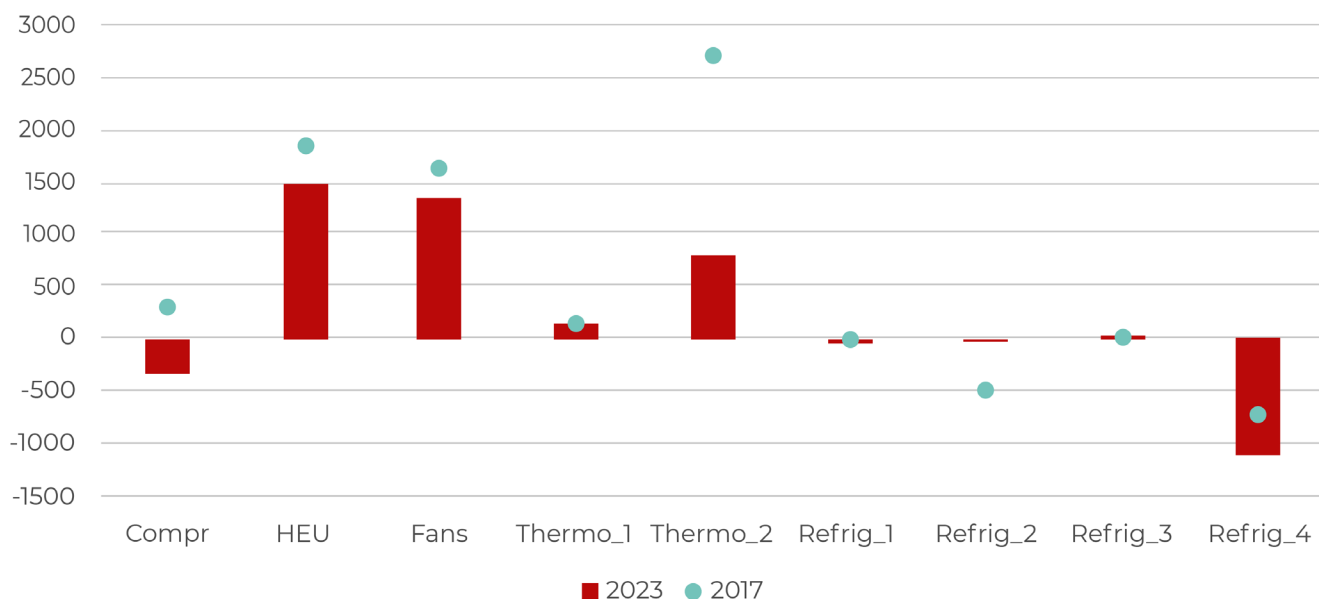
1. Fans and HEUs are components for which the EU exhibits strong and growing exports.
2. China is the leading global exporter across virtually all components.
3. Within the EU, Germany is the largest exporter for most components, while the Netherlands leads for refrigerants.
4. The EU is internationally competitive for HEUs, fans, thermostats and CO₂.
5. China is internationally competitive across most components. The USA has a comparative advantage for other controllers, HEUs, and fans; and Japan has a comparative advantage for other controllers, compressors, and HEUs.
6. Slovakia and Hungary are highly competitive for compressors; Sweden for HEUs.
7. The highest export unit values are observed for other controllers. The lowest prices, instead, are registered for refrigerants, although prices are generally increasing, particularly for ammonia.
8. EU export unit values are generally higher than those of China, but lower than those of the USA and Japan.
9. Changes in EU export unit values indicate broad-based quality upgrading across virtually all components.

5.3 Trade balances and import dependencies

This section aims to unveil the trade dependencies that the EU currently faces, as well as recent dynamics.

The EU's trade balance was positive for HEUs, fans, thermostats and other controllers but deteriorated across most heat pump components between 2017 and 2023 (Figure 14). HEUs, fans, thermostats and other controllers recorded trade surpluses, but these were generally smaller than in 2017. Compressors and ammonia recorded significant trade deficits, with the latter being the most pronounced. The most notable change was observed for compressors, where the trade balance shifted from a surplus to a deficit over the period, indicating a growing reliance on imports. Nevertheless, compressors registered a trade surplus again in 2024.¹²⁹ A similarly pronounced decline was recorded for other controllers: while this component generated the largest trade surplus in 2017, by 2023 it ranked only third among surplus-generating components.

Figure 14. EU trade balance, in millions of US dollars, for 2017 versus 2023.



Notes: Compr: compressors; Thermo_1: thermostats; Thermo_2: other controllers; Refrig_1: mixtures; Refrig_2: HFC-32; Refrig_3: CO₂; Refrig_4: ammonia.

Source: BACI database, wiiw calculation.

Import structures and trends can be described as follows (see Figure 15):

1. **Compressors:** the largest share of imports in 2023 originated from China (37%). Japan was the second-largest supplier (26%), followed by Thailand (12%). Between 2017 and 2023, China moved from second to first place, and Thailand gained positions. This shows that new players (even from emerging markets) are gaining relevance. Still, import concentration among the top five suppliers increased slightly over this period, with China's share rising from 29% in 2017 to 37% in 2023.
2. **HEUs:** the largest imports in 2023 came from China (28%), followed by the USA (18%) and the UK (15%). Between 2017 and 2023, the ranking of major suppliers changed slightly: China moved from second place to the leading import source, while the UK, Japan and Türkiye also improved their positions.

Russia ceased to be a relevant supplier, with its share already declining significantly from 2020. Neighbouring Western Balkan countries, Serbia and North Macedonia, also increased their shares during this period, although their contributions remained relatively small. Overall, the concentration among the top five import sources declined only slightly.

3. For **fans**, the main EU import source was China (37%), followed by the USA (12%) and Thailand (9%). The ranking remained largely unchanged, and the concentration among the top five import sources declined only marginally, indicating a consolidated, stable market.
4. For **thermostats**, approximately half of all imports in 2023 originated from China, while Tunisia accounted for 14% and the UK for 12%. The ranking of the main suppliers remained unchanged, although China significantly

expanded its share from 38% to 52%. This shows that, in this area, the EU might be developing a strategic dependence on China.

5. For **other controllers**, around one third of imports originated from China, the USA accounted for 20% and the UK for 12%. Between 2017 and 2023, China surpassed the USA. Overall, the concentration among the top five import sources increased slightly during this period, with China's share rising from 22% to 28%.

6. For **mixtures and HFC-32**, imports were overwhelmingly dominated by China in 2023, accounting for more than four fifths of total imports. Over the period 2017-2023, other suppliers, particularly the USA, Japan and the UK, lost market shares. It is also worth noting that, overall, these imports are negligible.

7. **CO₂ and ammonia** exhibit a markedly different and more diversified supply structure, in which China plays only a minor role. Imports of CO₂ were led by Norway, Israel and North Macedonia, with notable changes in supplier rankings over time but a stable concentration among the top five suppliers. For ammonia, the supplier structure changed substantially following Russia's aggression against Ukraine, which led to a sharp decline in Russia's share and a shift towards suppliers such as Algeria, Trinidad and Tobago, and Egypt.

Confirming the role of imports from China, the EU had a trade deficit in compressors, fans and HEUs in 2024, although the last of these registered a surplus in 2023.¹³⁰

Figure 15. Top five sources for EU imports of heat-pump components in 2017 and 2023, in % of total.

Compressors



HEUs



Fans



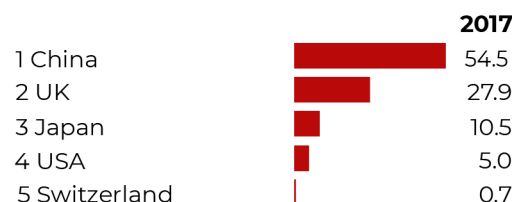
Thermostats



Other controllers



Mixtures



HFC-32



Carbon dioxide



Ammonia



Source: BACI database, wiiw calculation.

Looking at the entire value chain, interviewees highlighted continued dependencies on imported components (most notably semiconductors) and raw materials. Semiconductors were repeatedly identified as a critical input, with one stakeholder noting that even relatively simple fan and compressor systems require electronic components that are often sourced from Asia. The COVID-19 period was cited as evidence of these vulnerabilities, when shortages of semiconductors and other inputs disrupted production and, in some cases, led to heat pumps being delivered without fans.

The results in a nutshell:

1. HEUs, fans, thermostats and other controllers recorded trade surpluses in 2023. Compressors and ammonia recorded trade deficits, with the latter being the most significant.
2. Between 2017 and 2023, trade balances weakened across most heat pump components, with compressors and other controllers showing the largest deteriorations.
3. China emerged as the dominant import source in 2023, with the only exceptions of natural refrigerants.
4. More than half of the thermostats and approximately 80-90% of traditional refrigerants imported into the EU came from China.

5.4 The innovation profile

This section analyses EU-funded research project databases, academic and grey literature, company websites, and insights from interviews with industry stakeholders and experts (see Annex VI) to provide a qualitative assessment of the innovation efforts and capacities of EU countries across the various components analysed in this study. Because readily available quantitative indicators for these components and technological directions do not exist, we rely on a qualitative assessment. This means that the list of technological directions and innovations presented might not be fully exhaustive.

Characterising the nature and pace of innovation across heat pumps' components

Before assessing the EU's position in the global innovation landscape of heat pump components, Table 7 draws on insights from the literature review in Section 3 and the interviews conducted for this study to summarise the key innovation trajectories of each component (i.e., the areas that are the focus of R&D&I) and characterise the nature of technological change across the components, thereby distinguishing between mostly incremental and more radical forms of innovation.

For most heat pump components, innovation is largely incremental, consisting of continuous improvements to established technologies rather than fundamental breakthroughs (Table 7). These innovations primarily aim to reduce costs, improve energy and material efficiency, expand functionality, and enable faster installation.¹³¹ For **compressors**, for example, the range of innovation directions is broad, spanning from high-efficiency designs to early-stage innovations, such as electrochemical compression. Innovations around controllers can also be considered incremental, even though they would entail a more pervasive adoption of new digital technologies, including artificial intelligence. **Fans** follow the same pattern, with efficiency gains and noise reduction achieved through incremental design improvements. For example, the German global leader Ziehl-Abegg recently developed

biomimetic fan designs inspired by owl wings. Beyond reducing noise, this innovation also achieves greater efficiency.¹³² Indeed, the product was also developed to comply with the Ecodesign Directive (2009/125/EC), which is another important piece of legislation reshaping the industry and creating opportunities for innovation and differentiation that can translate into a competitive advantage over cheaper producers (most notably from China).

Despite this generalisable finding, a few innovations are considered to have the potential to change the industry at the component level. The most notable example is in the HEU domain. HEU-related innovations mostly represent adaptations of mature technologies that have been commercially deployed for decades. Still, industry experts point to the MCHE, which allows for the switch from copper to aluminium, increasing efficiency by 20%, and reducing the amount of refrigerants needed – with the latter being a significant improvement, given the higher flammability of natural refrigerants. Similarly, 3D-printed heat exchangers show great potential

and are believed to be the only credible alternative to plate HEUs (the dominant technology at the moment). Efforts like these can reshape the heat pump landscape in ways that go beyond incremental design improvements.

The only component for which the innovation dynamics could be described as radical is the switch to natural refrigerants. The basic research and innovation investments to optimise compressors and heat exchangers for natural refrigerants have already been undertaken,¹³³ but firms are actively developing commercial solutions.

While innovations across components are mostly incremental, innovations at the heat pump level could have major implications for component design, markets and innovation. For example, Blue Heart Energy, a spin-out of the applied science and technology organisation TNO, received EU EIC funding and has developed a thermoacoustic heat pump engine that eliminates the compressor and the refrigerants.

Table 7. The innovation trajectories and nature of technological change across the components.

Component	Innovation trajectories	Assessment of the nature of innovation
Compressors	High-efficiency compressors, electrochemical compressors, wider functionality and adaptation to natural refrigerants	Incremental
HEUs	MCHE and 3D printed HEU	Incremental and significant
	Need for continued innovation, quality differentiation, efficiency in terms of materials (allowing for high transfer of heat), reduction of refrigerants and oil, and adaptation to natural refrigerants	Incremental
Controllers	Smart controls, AI-enabled optimisation, digital twins, interoperability and grid integration	Incremental
Fans	Efficiency, noise reduction, customisation*	Incremental
Refrigerants	Natural refrigerants	Radical

* As one respondent remarked, while dimensions may be standardised, “not a single item is shipped to two people”, reflecting the high degree of customisation required.

Source: wiiw, based on literature and interviews.

The components researched under large EU projects

Table 8 presents six large EU-funded research projects under Horizon Europe and Horizon 2020 that involve heat pump components, with budgets ranging from approximately €2 million to €11 million. **The projects span a broad consortium of European countries, with Norway, Italy and Spain appearing most frequently as participating countries.** In three of the ten projects, these countries are listed first in the table, which indicates that they are consortium leaders. Leadership in these projects suggests stronger research capacity and institutional reputation in countries such as Norway, Italy and Spain. By contrast, Central and Eastern European countries appear less frequently, which is consistent with their weaker innovation systems. This contrast reinforces earlier findings that these countries are emerging as manufacturing hubs within the EU but

are less integrated into research and innovation networks.

Across all projects, natural refrigerants emerge as the dominant component of interest, featuring in the majority of initiatives – often in the form of ammonia or CO₂. HEUs and compressors also appear recurrently. Collectively, the projects reflect a strong pan-European research commitment to advancing sustainable and efficient heat pump technologies, with a particular emphasis on transitioning toward environmentally friendly refrigerants. It is also worth noting that, while fan design does not feature in recent Horizon projects, research in this area seemed more prominent under the EU's Seventh Framework Programme for Research and Technological Development and Demonstration Activities (FP7), which ran until 2013. Within FP7, compressors, HEUs and automation emerged as key technological areas, with research focusing on design aspects, thermal storage and system controls to minimise power consumption across system components.

Table 8. Projected funded by Horizon Europe and Horizon 2020 involving heat pump components.

Name of the project	Budget (million)	Countries involved (ordered by EU contribution)	Components involved
SPIRIT (Horizon Europe)	~€11	NL, DE, BE, DK, NO, CZ, IT	Ammonia and other natural refrigerants, compressors
GEO4CIVHIC (Horizon 2020)	~€8	IT, DE, ES, IR, RO, FR, MT, BE, EL	Natural refrigerants, HEUs
TRI-HP (Horizon 2020)	~€5	CH, NO, ES, DE, SE, BE	Natural refrigerants (CO ₂)
MultiPACK (Horizon 2020)	~€4	NO, IT, DK, PT	Natural refrigerants (CO ₂)
I-UPS (Horizon Europe)	~€2	SE, NO, PL, IT, ES	HEUs and compressors
ZIMBA (Horizon Europe)	~€2	FR, IT, CZ	Natural refrigerants (ammonia)

Source: wiiw, based on CORDIS database.

The EU position in the component innovation landscape

Table 9 lists some of the main areas of innovation in the most technologically complex heat pump components and briefly assesses the EU's position in each. It allows us to identify several areas of strength.

For compressors, industry experts agree on the overall assessment of the EU innovation efforts and capacities with respect to other global leaders. With IP largely Asian (Japanese) and US-based, some European firms (e.g., Danfoss) have retained critical know-how but have reduced their innovation efforts in this component. Indeed, the efforts of European manufacturers, German in particular, to enter the technological race with their Asian counterparts in the past decades have not managed to shake up the innovation landscape. For example, a US company (Copeland) and a Japanese one (Daikin) have undertaken a joint innovation project to improve compressor functionality at higher speeds.¹³⁴ Still, a few innovations are currently being pursued in Europe. For example, Europe pioneered oil-free centrifugal magnetic bearing technology – important technology for the industrial market that is about three times more efficient than a standard compressor. Danfoss was the first company to introduce this product, and now several other companies are introducing similar technologies. The German company ebm-papst also recently ramped up its R&D investments in compressor technologies, focusing especially on turbo compressors, a resilient and cheap alternative to standard compressors and a potentially disruptive innovation.¹³⁵ Europe also holds a strong position in design changes for natural refrigerant compatibility (Germany).

For **HEUs**, according to interviewees, the EU innovation positioning is truly solid. The EU company Alfa Laval possesses global-quality IP and may be the world's market leader. Regarding MCHE, the technological race to be the first to launch products on the market is still open (i.e., the technology is still in an R&D phase), with European companies (such as Danfoss) in a good position but facing competition from China. German companies are

in a potentially strong position for 3D-printed heat exchangers. Topology-optimised heat exchangers¹³⁶ are the subject of active research across Italy, Belgium, the Netherlands and Germany, though no EU commercial leader has yet emerged. Polymer and polymer-composite HEUs¹³⁷ are being actively researched in Denmark, Belgium, the Netherlands and France. Membrane-based HEUs are in a similar (pre-commercial) stage, with research currently underway mostly in Italy, the Czech Republic, Belgium, the Netherlands and Germany. In both cases, industrial applications are not yet available. Finally, while EU companies are well positioned in 3D-printed HEUs, China is generally strong in 3D-printing-related technologies, and the USA is investing heavily as well.

For **thermostats and controllers**, the relevant innovation at the unit level, namely, the application of AI, digital technology, digital twins and embedded intelligence, shows a moderate EU position, led by Italy and Denmark but challenged by important players in Asia.

A variety of EU firms are also working to adapt heat pump components to natural refrigerants. For example, the German company BITZER is among the few manufacturers that offer compressors for propane as well as ammonia, drawing on its long history in this niche. Companies such as Danfoss, Alfa Laval and SWEP are also introducing other innovations to HEUs to improve their performance with natural refrigerants. In this area, research is still needed to ensure safety, including end-of-life disposal, and to comply with the F-gas Regulation.¹³⁸

Table 9. Innovation areas for the main components and an assessment of the EU position.

Component	Innovation areas	EU MS active	EU position
Compressors	Inverter technology (now standard in the premium residential segment) rapidly moving down-market	none	Weak (JP tech)
	Vapor injection/two-phase injection technology for cold-climate performance	DK	Moderate , with Japan and USA also investing considerably
	Design changes for flammability safety and changes in materials for compatibility with natural refrigerants	DE	Strong , thanks to EU policy context
	Oil-free magnetic compressors	DK, DE	Strong : EU competing in the technological race
	Compressors for high-temperature heat pumps	DE	Strong , albeit Japan is also a strong player
	Smart/digitally integrated compressors	DK, DE	Strong
HEUs	MCHEs	DK	Moderate , Danfoss is the main player
	3D-printed heat exchangers	DE, IT, SE	Strong : some companies in a potentially good position, but facing difficulties in scaling
	Topology-optimised heat exchangers	IT, BE, NL, DE	Difficult to assess : research currently underway, but no EU company yet
	Polymer and polymer-composite heat exchangers	DK, BE, NL, FR	Difficult to assess : universities and research institutes actively researching, no industrial applications yet
	Membrane-based heat exchangers	IT, CZ, BE, NL, DE	Difficult to assess : research stage
Thermostats and other controllers	Application of AI & digital tech; digital twins and embedded intelligence	IT, DK	Moderate

Source: wiiw, based on desk research and interviews with industry stakeholders and experts.

The results in a nutshell:

1. Most of the components are technologically mature, with innovations being mostly incremental in nature.
2. The switch to natural refrigerants is the most innovative trend for components, also requiring innovations in compressors and HEUs.
3. Several large EU-funded projects focus on the transition to natural refrigerants.
4. European firms are technological leaders in the HEU segment, while also investing in other components, including compressors.
5. Innovation capacities are mostly concentrated in Western European countries.

5.5 A summary of the key findings of the study

Table 10 summarises the study's findings across the five components analysed. Two patterns are particularly salient:

1. Compressors combine the EU's largest cost share (25-30%) with its weakest position: production and competitiveness are declining, and the reliance on Chinese imports is growing.
2. HEUs are where EU firms hold the strongest position, despite rising competition from Asia: global leadership; solid production capacity; and continued innovation.

Table 10: A summary of the findings of the study.

Component	Key characteristics	Global landscape	EU production & trade	Competitive MS	EU innovation capabilities
Compressors	25-30% of heat pump cost; complexity varies by application (residential versus industrial)	Japan most competitive player (owns IP); China top global exporter; USA competitive (owns IP)	Declining production & competitiveness; rising CN imports; EU production in industrial segment partly retained	5 MSs competitive, with SK and HU more competitive than China	Overall moderate performance, due to established position and strong competition from Japan (and partly USA)
HEUs	~15% of heat pump cost; relatively standardised	EU global leader, with increasing pressure from China	Solid position in traditional players (IT, DE, FR, SE) and growing production in Central Eastern Europe	16 MSs competitive, with SE being a global top player	Very strong innovation capabilities, despite being mature technology
Fans	~8% of final value; relatively uncomplex	China top global exporter. EU traditional player, but rising imports from China	Strong production; still competitive but eroding position	7 MSs competitive, with IT and DE as major players	Good EU position, but limited prospects (incremental innovations)
Controllers	~25% of heat pump cost; products with a huge variety of applications	China and Japan with important role; EU smaller but important role	Limited and declining production; competitive in thermostats	17 EU MSs competitive, with strong controller industry in Central and Eastern Europe	Moderate role, facing strong competition from Asia
Refrigerants	EU shifting towards natural refrigerants; high number of applications	Traditional: China top global exporter; limited EU role Natural: other global players play a small role	Traditional: only NL; natural: production and competitiveness across several MS (FR, ES, NL, IT, DE)	Traditional: only NL competitive; natural: 11 MSs competitive	Strong performance and efforts to adapt components to natural refrigerants

Source: wiiw.

6. CONCLUSIONS AND POLICY IMPLICATIONS

The current EU industrial policy debate centres on how to reshore industrial production in the EU by scaling up component manufacturing within the EU.

This is especially the case for products necessary for the transition towards climate neutrality, where a strategy is needed to strengthen EU manufacturing and reap the benefits of the decarbonisation process. The current IAA proposal, which focuses on net-zero technologies and energy-intensive industries, provides a list of requirements that products would need to satisfy to be considered “Made in Europe”. Often, these requirements are expressed in terms of components. To contribute to these discussions, the study assessed the European production, trade performance and innovativeness of key heat pump components. By analysing the economic performance of compressors, HEUs, fans, controllers and refrigerants, the study provides a granular assessment of where the EU holds production capacities, competitive advantages and innovation leadership and how it compares to other global players, namely, China, the USA and Japan.

The main results can be summarised as follows.

In terms of **production**, four patterns emerge from the analysis. First, EU production levels are highest for HEUs and compressors. Second, production growth has been strongest for relatively standardised components such as fans and thermostats, while the expansion of other components, particularly compressors, has been more limited. Third, production remains concentrated in a small number of large Western European economies, although Central and Eastern European countries are playing an increasingly important role for several components. Fourth, several smaller MSs have experienced rapid growth, albeit often from a low initial base.

Consistent with these findings, the **export** data analysis suggests that HEUs are among the

components with the strongest and most solid export profile. Export capacities are widespread across the EU, particularly for some components, but traditional players (in Western Europe) and emerging hubs (in Central and Eastern Europe) stand out clearly in the analysis. Overall, the EU faces fierce competition with strong cost pressures, particularly from China. Competition is particularly fierce in the commercial segments, where competitiveness is largely driven by costs. Still, Chinese producers are also moving into higher-value segments, putting EU competitive advantages at risk.

Taken together, these findings reveal that, **while the EU is competitive for several components and particularly strong for HEUs, it remains dependent on imports for some components, most notably compressors and certain refrigerants.** While China’s growing role as a single supplier across multiple components further puts pressure on EU producers, this evolution does not indicate the development of a strategic dependency for the five heat pump components analysed here. While China’s growing role as a single supplier across multiple components further puts pressure on EU producers, none of these components can be currently considered as a strategic dependency.

Finally, **in terms of innovation efforts and performance, components appear to be largely mature technologies**, with incremental innovations mainly aimed at reducing costs, increasing efficiency and reducing the environmental footprint. **EU companies hold world-leading positions for HEUs**, combining global leadership with active research across several next-generation technologies. Compressors are, overall, the EU’s weakest area, with IP concentrated in Japan and the USA and recent unsuccessful attempts to gain in the global technological race. Nevertheless, EU firms retain strength in a few higher-value compressor niches and continue to introduce new designs

and innovations. For some components, several emerging technologies are the subject of active EU research but have not yet reached industrial application. **Innovation in the EU also appears to be strongly shaped by regulatory pressures**, particularly around natural refrigerants and energy efficiency.

These results provide solid empirical evidence to inform EU industrial policy debates, particularly in the context of Made in Europe policies. They allow to highlight which components could realistically be scaled up in the EU and assess whether scaling up makes strategic sense. **Industrial policies in the EU heat pump value chain should focus on components that can deliver manufacturing capacity and jobs, as well as innovation and added value.** Amid increasing competitive pressures (particularly from cost-competitive producers), EU policies cannot aim to restore EU cost competitiveness in standardised, low-value components. Such a strategy cannot be sustained in the medium to long term and would likely yield marginal benefits.

Based on the results, four key recommendations can be formulated.

First, HEUs emerge as the component for which an industrial policy (including in the form of Made in Europe requirements) would bring the strongest benefits. For this component, the EU combines significant production capacity, strong international competitiveness and leading innovation capabilities. Scaling up manufacturing capacity seems technically feasible, thanks to existing and newly established production capacity, strong control of relevant know-how, and clear differentiation strategies across major EU producers. As the global competitive landscape still leaves room for quality-driven competitiveness and innovation, EU producers are particularly well placed to reap the benefits of an assertive industrial policy. These characteristics make this component particularly strategic. Industrial policy support for HEUs would be needed to protect EU producers from increasingly pressing competition from Asia, requiring an approach tilted toward open strategic autonomy or even Made in EU requirements. Made in EU requirements could provide greater

certainty about future demand, enabling long-term investments in production expansion and innovation.

Second, continued regulatory ambition remains one of the EU's most powerful tools for sustaining the EU's competitiveness and innovation edge. In this value chain, the switch to natural refrigerants exemplifies the impacts of these policies, requiring innovations and adaptations throughout the value chain. Efforts to adapt to the new regulations should be supported under well-defined conditions to ensure that companies make the necessary investments and can carve out a large enough market for their green products.

Third, compressors may be a challenging target for EU policies aimed at increasing manufacturing capacity, but they still deserve policy support to protect existing EU capacity. Strong, sustained policy support would be needed to bring compressor production back to the EU, with unclear prospects regarding the success and concrete benefits of such a policy intervention (particularly if it does not target specific market segments). At the same time, compressors represent a large share of the heat pump's value, and several producers still maintain production in the EU and their own designs and IP. Some of these producers are making significant investments in compressor technologies. Finally, in the highest-value segments, competitors are Japanese, Korean and US firms. These insights suggest that the EU might still find a viable and profitable niche. Hence, policy support could still aim to protect existing production and promote innovations where technically worthwhile.

Finally, regardless of the targeted component, **policies should combine demand-side incentives**, aimed at stabilising demand and fast-tracking the adoption of heat pumps, with **supply-side incentives**, aimed at ensuring that EU producers can remain innovative and competitive. The policy mix to support component manufacturers should also include an **effective market surveillance system** to prevent European demand from being met by cost-competitive but lower-quality, less-sustainable products. In this regard, market surveillance would also contribute to the effective implementation of

other policy packages, including Made in Europe and the Ecodesign for Energy-Related Products Directive. Moreover, policies should also ensure that enough **skilled workers** are available in the EU to allow for a larger production scale.

ANNEX I: PRODCOM AND HS CODES

Table 11. HS codes, Prodcod codes and code descriptions.

Part	HS22 code	HS17 code	Prodcod code	HS description	Prodcod description
Compressors	841430	841430	28.13.23.00	Compressors; kind used in refrigerating equipment	Compressors for refrigeration equipment
HEUs	841950	841950	28.25.11.30	HEUs; not used for domestic purposes	HEUs
Fans	841459	841459	28.25.20.30	Fans: n.e.c. in item no. 8414.51	Axial fans (excluding table, floor, wall, window, ceiling or roof fans with a self-contained electric motor with an output ≤ 125 W)
Thermostats and regulators	903210	903210	26.51.70.15	Regulating or controlling instruments and apparatus; automatic type, thermostats	Electronic thermostats
	903289	903289	26.51.70.90	Regulating or controlling instruments and apparatus; automatic, other than hydraulic or pneumatic	Instruments and apparatus, regulating or controlling, n.e.c.
Refrigerant gases	382763	382478	20.59.59.71	Mixtures containing halogenated derivatives of methane, ethane or propane; containing other HFCs but not containing chlorofluorocarbons or hydrochlorofluorocarbons; other mixtures not included in the subheadings above	Mixtures containing halogenated derivatives of methane, ethane or propane, not elsewhere specified or included
	290342	290339	20.14.19.10	Saturated fluorinated derivatives of acyclic hydrocarbons: difluoromethane (HFC-32)	Saturated and unsaturated fluorinated, brominated or iodinated derivatives of acyclic hydrocarbons
	281121	281121	20.11.12.30	CO ₂	CO ₂
	281410	281410	20.15.10.75	Ammonia: anhydrous	Ammonia: anhydrous

Source: authors' elaboration, building on Directorate-General for Energy and ECORYS (2024).

ANNEX II: ASSESSMENT OF DATA QUALITY FOR PRODCOM DATA

Table 12. Assessment of data quality for Prodcom data.

Part	Prodcom code	Prodcom description (shortened)	Important players	Average, min. and max. share of EU MS aggregate vs EU27 aggregate	Data issues
Compressors	28.13.23.00	Compressors for refrigeration equipment	DK, DE, FR, BE, IT	78% (97% in 2021 – 67% in 2017)	BE & DK: missing for all years Some secondary players (e.g., AT & NL): incomplete or blank
HEUs	28.25.11.30	HEUs	DE, IT, FR, SW, PL	98% (100% in 2023 – 91% in 2022)	HU & AT: missing all or most years
Fans	28.25.20.30	Axial fans	DE, IT, FR, NL, DK	98% (100% in 2017 – 95% in 2021)	HU & SK: missing most years
Thermostats and regulators	26.51.70.15	Electronic thermostats	DE, FR, DK, IT, ES	87% (96% in 2018 – 73% in 2022)	FR & HU: missing values post 2021, SK missing values before 2024
	26.51.70.90	Regulating or controlling instruments and apparatus; automatic, other than hydraulic or pneumatic	FR, DE, IT	77% (87% in 2022 – 74% in 2019)	RO: missing values before 2020 HU: missing values between 2019 and 2021
Refrigerant gases	20.59.59.71	Mixtures containing halogenated derivatives of methane, ethane or propane		1% (3% in 2018 – 0.01% in 2022)	Almost all countries: missing
	20.14.19.10	Saturated and unsaturated fluorinated, brominated or iodinated derivatives of acyclic hydrocarbons	FR, DE, IT	73% (99% in 2021 – 49% in 2017)	IT: missing values for most years
	20.11.12.30	CO ₂		91% (100% in 2021 – 78% in 2024)	BG & SE: missing values for almost all years
	20.15.10.75	Ammonia: anhydrous	DE, FR, ES, PL	47% (58% in 2021 – 29% in 2022)	SE missing values for most years

Notes: the average, minimum (min.) and maximum (max.) share of missing values are computed as the difference between the value of EU27 products sold as reported by Prodcom and the sum of the values of each of the EU27 MSs. Discrepancies reflect confidential data, particularly when one or a few producers are active in the market.

Source: authors' elaboration.

ANNEX III: ADDITIONAL PRODUCTION DATA

Table 13. Heat pump component production in 2023, in euros or kilograms.

	Compr	HEU	Fans	Thermo_1	Thermo_2	Refrig_2	Refrig_3	Refrig_4
AT	65,186,500		-		-	-	158,344,688	
BE			85,835,000		-	-	384,911,025	
BG	-	1,690,868	8,022,293	4,142,550	-	-		
HR	-	4,591,000	1,909,000	-	-	-	7,456,000	656,000
CY	-	-	-	-	-	-	-	-
CZ	329,759,748	6,925,738	246,797,575	9,906,141	-	-		
DK		45,368,211	138,336,711	116,030,144	-	16,786		
EE	5,700,000	58,000	149,000	2,431,000	5,000	-	-	-
FI	-	25,000	178,751,000	509,000	377,000	-	152,058,300	-
FR	262,828,000	109,545,000	723,071,000		137,588,000			225,467,232
DE	996,032,000	807,636,000	1,331,451,000	365,628,000	135,287,000	-		
EL	-	-	1,111,000		-	-	20,863,432	
HU			-		-		249,106,000	
IE			-		-	-		-
IT	150,897,000	315,813,000	1,911,014,000	110,749,000	134,199,000		217,862,000	
LV	-	-	-		-	-		-
LT	646,000	223,000	807,000	261,000	50,000	-	-	2,466,615
LU	-	-	-	-	-	-	-	-
MT	-	-	-	-	-	-	-	-
NL		46,588,000	222,457,000		-		1,247,304,000	
PL		23,934,170	457,852,488		-	-	650,263,000	68,353,000
PT	324,042,000		2,463,000	-	-	-		-
RO	-		28,057,695	-	691,370	-		83,783
SK	268,097,000	21,755,000	-		-	-	-	15,848,127
SI	-		-		-			-
ES	58,373,000	34,018,000	168,757,000	29,137,000	6,101,000		853,189,000	140,065,000
SE	-	3,299,997	672,422,640	2,038,453	-	-		
EU	2,946,673,433	1,444,000,000	6,000,000,000	24,000,000	550,000,000	5,740,486,178	2,000,000,000	825,354,525

Note: Compr: compressors; Thermo_1: thermostats; Thermo_2: other controllers; Refrig_2: HFC-32; Refrig_3: carbon dioxide; Refrig_4: ammonia. Compr, HEU, fans and Thermo_1 in euros, Refrig_2, Refrig_3, Refrig_4 in kilograms.

Source: Prodcorn database, wiiw calculation.

Table 14. Heat pump component production growth rates, 2017-2023.

	Compr	HEU	Fans	Thermo_1	Thermo_2	Refrig_2	Refrig_3	Refrig_4
AT	29.5%							
BE			70.0%				419.9%	
BG		141.9%	758.3%	1323.9%				
HR		63.2%	82.3%				-78.7%	-19.7%
CY								
CZ	-0.3%	18.2%	48.0%	313.6%				
DK		72.1%	141.9%	118.0%		-92.5%		
EE			-89.6%	-48.9%	-99.9%			
FI		-90.9%	43.3%	-35.9%	632.5%		-19.6%	
FR	-33.6%	41.8%	20.3%		28.7%			-16.1%
DE	33.8%	12.6%	23.1%	-1.2%	-17.8%			
EL			6.3%				133.0%	
HU					-100.0%		102.0%	
IE								
IT	-33.7%	56.2%	8.2%	55.0%	-85.4%		-28.2%	
LV								
LT		50.3%	60.6%	8276.1%				-23.9%
LU								
MT								
NL		-30.7%	23.2%				50.2%	
PL		61.9%	93.2%				-1.7%	-75.3%
PT			-64.5%					
RO			40.0%					
SK								6.0%
SI								
ES	-30.7%	-15.0%	42.3%	70.6%	-67.7%		81.5%	
SE			21.2%					
EU	7.4%	15.1%	23.2%	26.7%	4.9%	-7.2%	51.0%	37.3%

Note: Compr: compressors; Thermo_1: thermostats; Refrig_2: HFC-32; Refrig_3: carbon dioxide; Refrig_4: ammonia.
Source: Prodcorn database, wiiw calculation.

ANNEX IV: ADDITIONAL FIGURES ON EXPORTS

Table 15. Export growth rates of EU MSs, the USA, China and Japan, 2023 versus 2017 (in %).

	Compr	HEU	Fans	Thermo_1	Thermo_2	Refrig_1	Refrig_2	Refrig_3	Refrig_4
AT	-22.6	47.1	36.1	-17.6	95.8	-99.0	.	-12.5	28.0
BE	-37.5	21.0	180.4	-64.5	18.3	-98.8	-100.0	1084.0	-83.4
BG	1397.4	269.8	84.4	-5.4	-23.7	.	.	1900.4	37.9
HR	826.8	163.0	134.1	60.7	-37.1	-88.5	-96.7	-75.9	-77.3
CY	-85.1	18.2	290.2	5008.6	-95.4	.	.	.	.
CZ	-24.8	11.3	30.3	49.8	7.4	-97.8	.	1137.9	-99.5
DK	109.2	10.7	74.9	-38.4	-48.3	-57.9	-88.7	-10.8	113.7
EE	704.7	-43.4	-13.3	72.2	103.8	.	.	126.7	.
FI	145.6	35.5	-43.0	-62.0	9.6	.	.	-5.4	.
FR	-29.8	27.8	11.5	69.0	-13.0	-97.1	-99.8	140.7	1145.5
DE	21.2	6.0	9.6	28.6	-52.7	-69.4	-99.9	130.7	265.0
EL	32.8	150.1	14.6	116.9	104.7	-99.7	-99.6	77.3	-98.5
HU	-27.5	7.4	44.4	0.4	-58.5	.	.	146.7	65267.7
IE	-32.6	-10.7	107.0	6.2	-61.2	3581.6	692.3	39.4	272.8
IT	-2.7	-18.4	36.7	10.9	-19.4	-57.8	-99.4	46.0	-91.6
LV	4.3	18.7	-45.6	123.3	706.8	3574.9	.	24175.0	-100.0
LT	-48.7	-58.6	-64.6	-6.7	49.1	.	.	-21.3	134.6
LU	347.4	399.9	-39.7	-30.1	64.5	.	.	3010.8	.
MT	-35.7	-81.0	-16.8	-20.2	155.7	.	.	.	.
NL	23.2	2.8	-16.5	-46.9	0.7	-72.6	-99.3	51.5	30.7
PL	-4.2	51.9	35.4	54.5	54.7	.	-96.2	96.3	22884.7
PT	53.1	705.3	-29.1	90.2	-47.5	.	-96.4	106.6	-58.2
RO	-89.8	187.6	-39.7	181.8	-4.3	.	.	38.7	8.8
SK	-28.4	55.4	286.2	-51.3	-4.7	.	.	-96.4	.
SI	-36.5	35.4	-3.4	-45.7	-26.2	.	.	-31.0	.
ES	-53.9	-10.4	7.5	0.7	-20.3	-99.3	-98.8	105.6	-94.2
SE	86.6	10.1	-27.9	-15.4	-23.8	255.1	-90.7	-25.5	-5.4
TOTAL	-7.2	8.1	16.7	18.8	-31.3	-81.2	-99.5	66.1	-51.0
US	-2.4	43.3	49.3	22.1	-14.7	-77.9	-98.1	84.5	204.1
CN	31.3	75.7	51.0	-7.6	11.4	-42.4	-89.5	456.0	3282.1
JP	36.6	33.4	71.0	-35.3	-3.1	-75.2	-98.5	8.4	-12.7

Note: Compr: compressors; Thermo_1: thermostats; Thermo_2: other controllers; Refrig_1: mixtures; Refrig_2: HFC-32; Refrig_3: carbon dioxide; Refrig_4: ammonia.

Source: BACI database, wiiw calculation.

Table 16. RCAs for EU MSs, the USA, China and Japan in 2023.

	Compr	HEU	Fans	Thermo_1	Thermo_2	Refrig_1	Refrig_2	Refrig_3	Refrig_4
AT	0.34	1.75	0.61	0.29	1.11	0.00	.	2.57	0.03
BE	0.29	0.82	0.48	0.10	0.65	0.02	0.00	1.70	0.03
BG	0.22	0.47	0.22	1.25	1.28	.	.	0.03	3.63
HR	0.67	1.23	0.57	4.52	0.47	0.18	0.03	0.30	0.02
CY	0.03	0.01	0.16	0.10	0.03	0.15	.	.	.
CZ	1.77	1.79	0.89	3.57	3.08	0.01	.	2.58	0.00
DK	0.85	1.13	1.38	1.70	1.05	0.04	0.02	0.63	0.02
EE	1.36	0.32	0.88	1.91	2.42	.	.	6.46	.
FI	0.11	2.45	0.51	0.14	1.60	.	.	0.09	.
FR	0.92	2.42	0.65	1.79	1.53	0.12	0.03	0.56	0.03
DE	1.32	1.73	2.41	1.69	1.39	0.04	0.01	0.48	0.04
EL	0.04	0.30	0.17	0.08	0.10	0.00	0.00	0.20	0.00
HU	2.33	1.92	2.81	1.03	3.75	.	.	3.03	0.00
IE	0.02	0.02	0.03	0.10	0.04	0.51	0.03	0.06	0.00
IT	0.66	2.87	3.03	1.75	0.48	0.25	0.03	0.21	0.00
LV	0.08	1.02	0.06	0.38	3.30	.	.	0.01	0.00
LT	0.14	0.28	0.28	0.52	0.57	0.02	.	1.60	0.27
LU	0.08	0.21	0.22	2.44	1.65	.	.	0.04	0.00
MT	0.01	0.29	0.06	0.07	0.46	.	.	0.01	.
NL	0.24	0.86	0.48	0.27	0.57	1.95	0.33	5.02	0.13
PL	0.84	2.47	0.96	1.11	2.91	.	0.01	2.31	0.02
PT	3.04	1.48	0.19	0.95	0.38	.	0.05	0.98	0.00
RO	0.17	2.62	1.29	1.69	6.34	.	.	0.35	0.00
SK	8.12	1.84	1.69	0.94	0.80	.	.	0.00	.
SI	0.06	1.06	1.41	0.77	0.33	.	.	0.04	.
ES	0.29	0.98	1.00	0.64	1.06	0.01	0.01	1.03	0.01
SE	0.10	3.37	0.54	0.41	1.09	0.17	0.10	2.01	0.03
EU	0.89	1.74	1.48	1.23	1.23	0.23	0.04	1.10	0.06
US	1.03	1.30	1.07	0.69	1.46	0.34	0.67	0.93	0.71
China	1.96	1.00	1.66	1.31	0.84	2.96	4.00	0.43	0.10
Japan	3.33	1.06	0.91	0.65	4.10	0.17	0.65	0.30	0.00

Note: Compr: compressors; Thermo_1: thermostats; Thermo_2: other controllers; Refrig_1: mixtures; Refrig_2: HFC-32; Refrig_3: carbon dioxide; Refrig_4: ammonia.

Source: BACI database, wiiw calculation.

Table 17. RCA changes in percentage points for EU MSs, the USA, China and Japan, 2023 versus 2017.

	Compr	HEU	Fans	Thermo_1	Thermo_2	Refrig_1	Refrig_2	Refrig_3	Refrig_4
AT	-0.17	0.08	-0.07	-0.14	0.58	-0.03	.	-2.81	-0.01
BE	-0.15	0.04	0.27	-0.18	0.23	-0.60	-0.50	1.48	-0.20
BG	0.20	0.27	0.02	-0.55	-0.45	.	.	0.03	-0.89
HR	0.59	0.54	0.18	0.89	-0.26	-0.75	-0.04	-2.07	-0.10
CY	-0.24	-0.00	0.10	0.10	-0.60	.	.	.	.
CZ	-0.80	-0.36	-0.09	0.79	0.54	-0.31	.	2.22	-0.00
DK	0.40	-0.23	0.25	-1.52	-0.75	-0.01	0.01	-0.60	0.01
EE	1.20	-0.33	-0.38	0.79	1.51	.	.	2.16	.
FI	0.06	0.27	-0.66	-0.24	0.43	.	.	-0.06	.
FR	-0.31	0.25	-0.07	0.73	0.19	-1.71	-0.81	0.21	0.03
DE	0.29	-0.15	-0.31	0.37	-0.86	-0.02	-0.33	0.17	0.03
EL	-0.00	0.10	-0.09	0.03	0.05	-0.40	-0.04	-0.04	-0.01
HU	-1.51	-0.69	-0.25	-0.28	-4.99	.	.	0.70	0.00
IE	-0.01	-0.01	0.01	-0.02	-0.05	0.50	0.03	-0.02	0.00
IT	-0.07	-1.74	-0.09	-0.06	-0.04	-0.06	-0.28	-0.03	-0.00
LV	-0.02	-0.36	-0.14	0.14	2.86	0.04	.	0.01	-1.13
LT	-0.19	-0.74	-1.00	-0.21	0.19	.	.	-2.36	0.08
LU	0.05	0.13	-0.50	-3.16	0.43	.	.	0.04	.
MT	-0.01	-3.15	-0.11	-0.10	0.19	.	.	.	.
NL	0.07	-0.04	-0.19	-0.21	0.17	-1.14	-2.32	0.39	0.01
PL	-0.11	0.31	-0.05	0.28	1.26	.	-0.01	0.28	0.02
PT	0.91	1.24	-0.19	0.38	-0.25	.	-0.04	0.17	-0.00
RO	-1.88	1.25	-2.18	0.90	-0.27	.	.	-0.15	-0.00
SK	-9.23	-0.37	0.81	-2.22	-0.24	.	.	-0.33	.
SI	-0.17	-1.29	-3.31	-2.95	-0.56	.	.	-0.20	.
ES	-0.36	-0.40	-0.27	-0.06	-0.05	-0.38	-0.04	0.21	-0.12
SE	0.04	-0.62	-0.51	-0.14	-0.14	0.14	0.03	-2.55	-0.02
EU	-0.09	-0.26	-0.22	0.10	-0.25	-0.38	-0.46	0.03	-0.10
US	-0.13	0.08	0.03	0.02	-0.07	-0.49	-1.60	0.05	0.36
China	0.19	0.17	-0.05	-0.49	0.12	-0.06	1.30	0.28	0.10
Japan	1.22	0.22	0.30	-0.28	1.13	-0.13	-1.66	-0.08	-0.00

Notes: Compr: compressors; Thermo_1: thermostats; Thermo_2: other controllers; Refrig_1: mixtures; Refrig_2: HFC-32; Refrig_3: carbon dioxide; Refrig_4: ammonia. The figures are based on extra-EU exports. Cells coloured in green indicate that the country has an RCA in that component, while cells coloured in red indicate a comparative disadvantage.

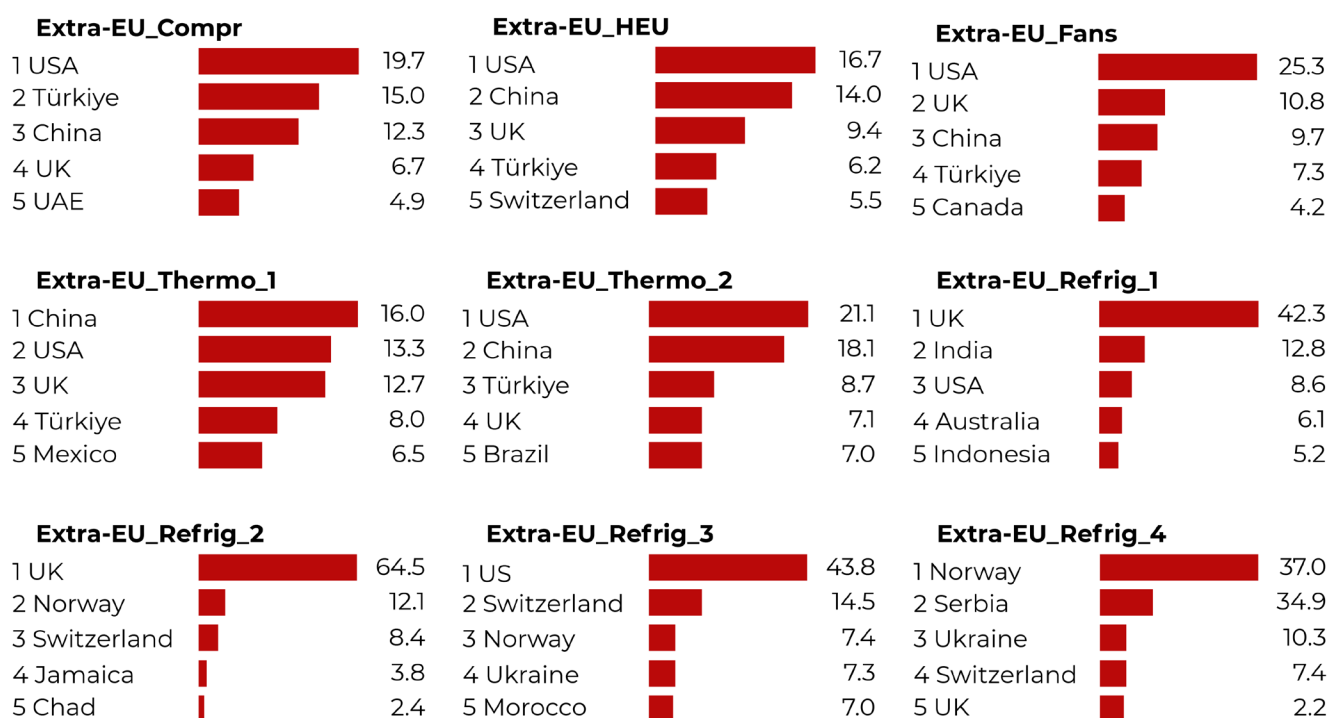
Source: BACI database, wiiw calculation.

ANNEX V: MAIN DESTINATIONS OF EU EXPORTS VERSUS USA, CHINA AND JAPAN

Figure 16 presents the main destinations of EU exports. The US, the UK and China account for the most significant shares of exports overall, while Norway is the primary destination for ammonia. Türkiye, Switzerland and Norway also feature prominently as key export destinations across

several components. Exports of most refrigerant gases are highly concentrated, with 42%, 65% and 44%, respectively, directed to the UK. For ammonia, 37% of extra-EU exports are shipped to Norway, while 35% go to Serbia.

Figure 16. Ten main export destinations for extra-EU exports (in % of total).



Source: BACI database, wiiw calculation.

The main export destinations for heat pump components from the USA, China and Japan are shown in Figure 17. US exports exhibit a relatively high degree of concentration, with Mexico and Canada accounting for the largest shares in most components, except for some refrigerants, which seem to require different trade partners. As noted

for the case of intra-EU trade, this finding points to the relevance of regional value chains.

China's exports are more diversified across a broad range of partner countries, although the USA and Japan remain key destinations. Mexico, Thailand and Germany also rank among the main destinations for several components. Ammonia stands out due

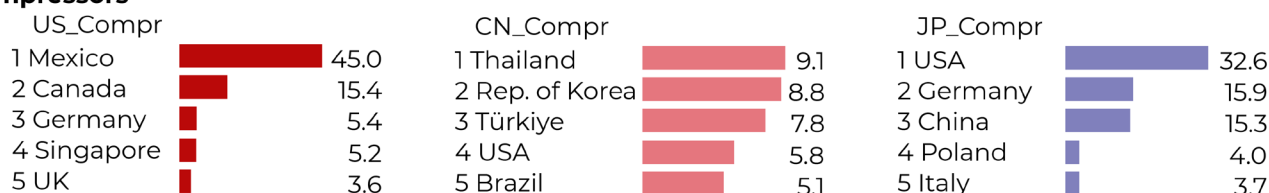
to a particularly high degree of export concentration, with India as the primary destination, followed by Vietnam and Thailand.

Japan's exports are also comparatively concentrated, with the USA and China serving as the principal markets. For compressors, Germany, Poland and

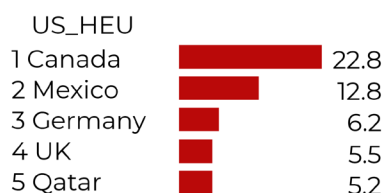
Italy additionally feature among the main export destinations, alongside the USA and China. Overall, the refrigerant markets are substantially more concentrated for all major exporters, but the degree of concentration is particularly pronounced in Japan. For mixtures, exports are directed exclusively to two destinations: other Asian countries and the USA; 83% of Japanese ammonia is shipped to China.

Figure 17. Five main export destinations for the USA, China and Japan (in % of total).

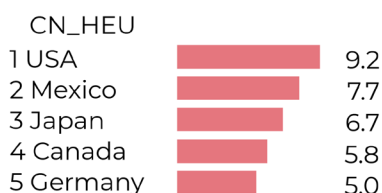
Compressors



HEU US



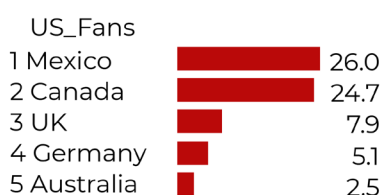
China



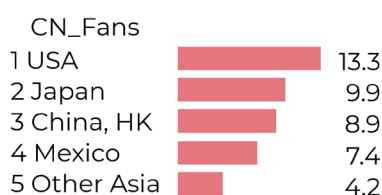
Japan



Fans US



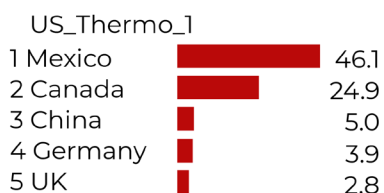
China



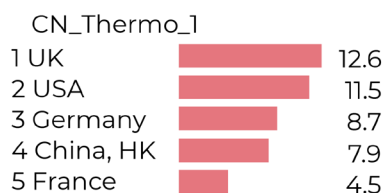
Japan



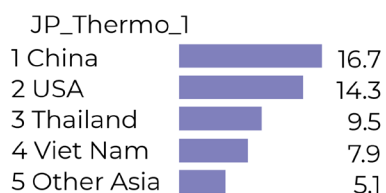
Thermostats US



China

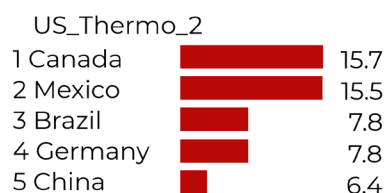


Japan

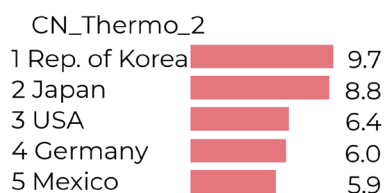


Other controllers

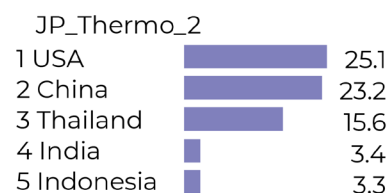
US



China



Japan

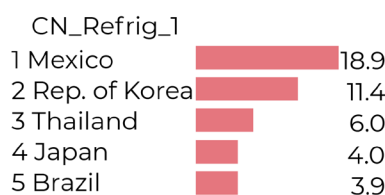


Mixtures

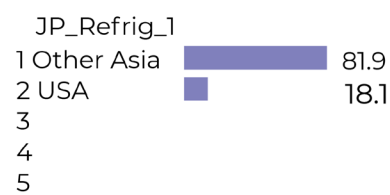
US



China

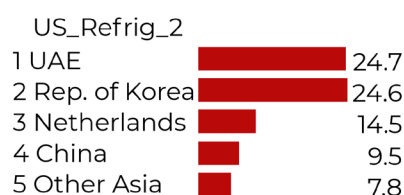


Japan

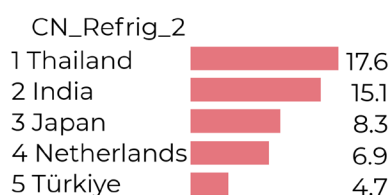


HFC-32

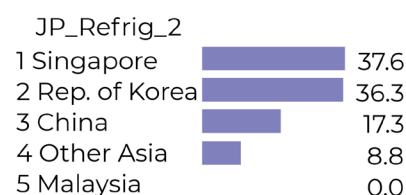
US



China

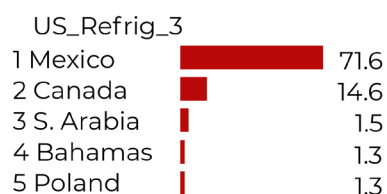


Japan

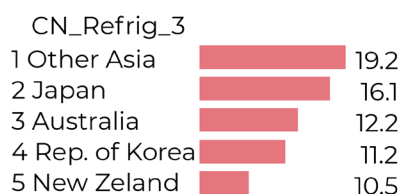


Carbon dioxide

US



China

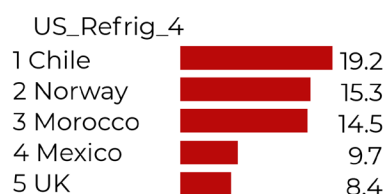


Japan

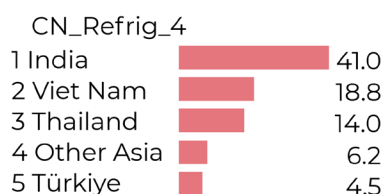


Ammonia

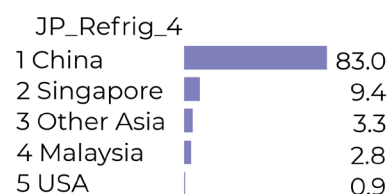
US



China



Japan



Source: BACI database, wiiw calculation.

ANNEX VI: LIST OF STAKEHOLDERS INTERVIEWED BY COMPONENT

Component	Stakeholder interviewed
All components	European Heat Pump Association
	Wärmepumpe Austria
	Directorate C – Energy, Mobility & Climate, Unit C.7: Energy Transition Insights for Policy, Joint Research Centre
	Building Heat Pump, Group Vapor Compression Technology, Fraunhofer Institute for Solar Energy Systems ISE
Compressors	Danfoss Climate Solutions
	Copeland Europe GmbH
Heat exchangers	Danfoss Climate Solutions
	SWEP International AB
Fans	Ziehl-Abegg

ENDNOTES

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- 9 Draghi, M. (2024) "Report on the future of European competitiveness: A competitiveness strategy for Europe – part B: In-depth analysis and recommendations".
- 10 For example: Volt, J., A. Toleikyte, J. C. Roca Reina et al. (2025) "Clean Energy Technology Observatory: Heat pumps in the European Union - 2025 status report on technology development, trends, value chains and markets".
- 11 "About heat pumps". EHPA.
- 12 "EU hydronic heat pump manufacturing market assessment: Technical report". Eunomia.
- 13 Sirtori, E., S. Banfi, G. Canzian et al. (2024) "SMEs and open strategic autonomy – final report".
- 14 "EU hydronic heat pump manufacturing market assessment: Technical report". Eunomia; Lyons, L., E. Lecomte, A. Georgakaki et al. (2023) "Clean Energy Technology Observatory: Heat pumps in the European Union - 2023 status report on technology development, trends, value chains and markets". Publications Office of the European Union. DOI: 10.2760/69478
- 15 Hydronic heat pumps are particularly significant in Europe, where water-based heating systems dominate the residential stock and where district heating is expanding. Because they can decarbonise both individual buildings and industrial process heat, they form the backbone of the EU's residential and industrial decarbonisation strategy (Lyons et al., 2024). These systems are contrasted with air-to-air heat pumps, which directly heat indoor air and are dominant in Asia and North America. „EU hydronic heat pump manufacturing market assessment: Technical report". Eunomia; Lyons, L., E. Lecomte, A. Georgakaki et al. (2023) "Clean Energy Technology Observatory: Heat pumps in the European Union - 2023 status report on technology development, trends, value chains and markets".
- 16 Steinwender, L. (2024) "Large-scale heat pumps in Europe: A review of the status quo and the competitiveness of different heat sources". Master's thesis. TU Wien; Toleikyte, A., E. Lecomte, J. Volt et al. (2024) "Clean Energy Technology Observatory: Heat pumps in the European Union - 2024 status report on technology development, trends, value chains and markets".
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- 18 Toleikyte, A., J. C. Roca Reina, J. Volt et al. (2023) "The heat pump wave: Opportunities and challenges".
- 19 "Investment needs assessment and funding availabilities to strengthen EU's net-zero technology manufacturing capacity". Commission staff working document, SWD(2023) 68 final. European Commission, 23 March 2023.
- 20 Volt, J., A. Toleikyte, J. C. Roca Reina et al. (2025) "Clean Energy Technology Observatory: Heat pumps in the European Union - 2025 status report on technology development, trends, value chains and markets".
- 21 "EU hydronic heat pump manufacturing market assessment: Technical report". Eunomia.
- 22 Volt, J., A. Toleikyte, J. C. Roca Reina et al. (2025) "Clean Energy Technology Observatory: Heat pumps in the European Union - 2025 status report on technology development, trends, value chains and markets".
- 23 Refrigerants are contained within the sealed circuit of a heat pump and are not released during normal operation. Leaks can occur but are subject to regulatory controls, including mandatory leak checks and recordkeeping requirements under the EU F-gas Regulation. Lyons, L., E. Lecomte, A. Georgakaki et al. (2023) "Clean Energy Technology Observatory: Heat pumps in the European Union - 2023 status report on technology development, trends, value chains and markets".

Union - 2023 status report on technology development, trends, value chains and markets”.

24 It is worth noting that, while natural refrigerants such as propane (R290) and CO₂ (R744) have far lower global warming potentials (GWPs) than HFCs, they are not entirely without climate impact in the event of leakage. Propane has a GWP of three and CO₂ a GWP of one, compared to 2,088 for R410A. Propane also requires additional safety precautions due to its flammability. Overall, however, the environmental profile of natural refrigerants is substantially better than that of HFCs. Lyons, L., E. Lecomte, A. Georgakaki et al. (2023) “Clean Energy Technology Observatory: Heat pumps in the European Union - 2023 status report on technology development, trends, value chains and markets”.

25 PFAS are widely used, long-lasting chemicals. Many HFCs, including R410A and R134a, are classified as PFAS.

26 Lyons, L., E. Lecomte, A. Georgakaki et al. (2023) “Clean Energy Technology Observatory: Heat pumps in the European Union - 2023 status report on technology development, trends, value chains and markets”.

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29 Estimates collected via stakeholder consultations.

30 This paragraph is based on insights collected from stakeholder consultations.

31 “EU hydronic heat pump manufacturing market assessment: Technical report”. Eunomia; Lyons, L., E. Lecomte, A. Georgakaki et al. (2023) “Clean Energy Technology Observatory: Heat pumps in the European Union - 2023 status report on technology development, trends, value chains and markets”.

32 Toleikyte, A., J. C. Roca Reina, J. Volt et al. (2023) “The heat pump wave: Opportunities and challenges”; “EU hydronic heat pump manufacturing market assessment: Technical report”. Eunomia.

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37 Toleikyte, A., J. C. Roca Reina, J. Volt et al. (2023) “The heat pump wave: Opportunities and challenges”.

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44 Toleikyte, A., J. C. Roca Reina, J. Volt et al. (2023) “The heat pump wave: Opportunities and challenges”.

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56 Lyons, L., E. Lecomte, A. Georgakaki et al. (2023) „Clean Energy Technology Observatory: Heat pumps in the European Union - 2023 status report on technology development, trends, value chains and markets“.

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- 79 Ibid.
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- 86 However, doubts remain about whether trade statistics reflect actual manufacturing capacity, as Romania may primarily act as an assembler.
- 87 Toleikyte, A., E. Lecomte, J. Volt et al. (2024) "Clean Energy Technology Observatory: Heat pumps in the European Union - 2024 status report on technology development, trends, value chains and markets".
- 88 "Investment needs assessment and funding availabilities to strengthen EU's net-zero technology manufacturing capacity". European Commission.
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114 From aggregate data alone, it would be challenging to infer the employment potential of different components, particularly since they belong to the same broader industry.

115 Production data at a highly disaggregated level are not available for countries outside the EU; even within the EU, they are often subject to confidentiality restrictions. This is mostly because, with narrowly defined products, producers are often very few.

116 Compressors are also used in refrigerators, freezers and air-conditioning systems. HEUs are present in refrigerators and automobile radiators, as well as in other cooling applications such as in data centres. Fans are also widely used, for example, in air-conditioning systems, hairdryers and e-vehicle charging stations. For controllers, additional uses are many, including washing machines, refrigerators and ovens. Refrigerants are also used in a plethora of products, such as air-conditioning systems and refrigerators, and well beyond these industries, including agriculture and chemicals.

117 According to Prodcom metadata, production value is defined as the number of products manufactured at any time and sold (invoiced) during the reference period.

118 Insights from stakeholder interviews.

119 This paragraph builds on stakeholder interviews.

120 Residential heat pumps generally rely on split systems.

121 Insights from stakeholder interviews.

122 Toleikyte, A., E. Lecomte, J. Volt et al. (2024) “Clean Energy Technology Observatory: Heat pumps in the European Union - 2024 status report on technology development, trends, value chains and markets”.

123 According to insights collected through interviews, compressor plants in Europe only assemble compressors and no manufacturing takes place within the EU, as mentioned in the previous section.

124 Slovakia and Czechia each account for roughly 12% of EU production, while Hungary contributes around 8%.

125 According to insights collected through interviews, the key companies manufacturing fans in the EU are two German companies: EBM Papst and Ziehl-Abegg.

126 EU producers are leaders in the brazed-plate heat exchanger market.

127 See also: “Europe’s heat pumps are mainly ‘made in Europe’”. EHPA, 9 April 2026.

128 It is worth specifying here that refrigerants are used in a great variety of industries. For example, ammonia is very important in making fertiliser and in the chemical industry, and carbon dioxide for food preservation, as well as a variety of other industrial applications.

129 Volt, J., A. Toleikyte, J. C. Roca Reina et al. (2025) "Clean Energy Technology Observatory: Heat pumps in the European Union - 2025 status report on technology development, trends, value chains and markets".

130 Ibid.

131 Insights from interviews with industry experts and stakeholders.

132 The interviewee specifically mentioned a 5% improvement in efficiency and noted that further improvements could be achieved with continuous innovation.

133 Toleikyte, A., E. Lecomte, J. Volt et al. (2024) "Clean Energy Technology Observatory: Heat pumps in the European Union - 2024 status report on technology development, trends, value chains and markets".

134 Based on interviews.

135 See for example: "ebmpapst eröffnet HighSpeed-Technikum". ebm-papst, 9 December 2024.

136 These HEUs use mathematical algorithms to maximise thermal efficiency.

137 Unlike traditional metal units, these HEUs use plastics, saving on copper. As a result, they are much lighter, cheaper and highly corrosion resistant. These characteristics reduce costs (including maintenance, transportation and installation) and save energy. These HEUs are also easier to manufacture than traditional HEUs. Still, this technology faces technical challenges, particularly because it is difficult for plastics to contain pressure.

138 Toleikyte, A., E. Lecomte, J. Volt et al. (2024) "Clean Energy Technology Observatory: Heat pumps in the European Union - 2024 status report on technology development, trends, value chains and markets".

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AI DISCLOSURE STATEMENT

This publication was written in accordance with FEPS guidelines on the responsible use of AI in research and writing activities.

The authors used generative AI tools at various stages of the research process.

1. To process large amount of information and enhance the understanding of the technical aspects of the technologies at hand.
2. Information retrieval: screen and characterise relevant projects from the CORDIS database, identify relevant company news items.
3. Word processing: editing assistance, rewriting for clarity.

The authors verified all information gathered through the AI tools directly, via desk research and experts' interviews. The analysis, findings, and conclusions are entirely those of the authors.

Europe's decarbonisation-competitiveness debate has placed industrial policy at the centre of the EU's policy agenda. Since the Draghi Report of September 2024, a succession of EU initiatives – the Competitiveness Compass, the Clean Industrial Deal, and now the Industrial Accelerator Act (IAA) – have sought to reconcile decarbonisation with competitiveness, including through “Made in Europe” requirements expressed at the level of individual components. This study takes the heat pump industry as a case study to identify which components should be prioritised for support to accelerate EU manufacturing, advance on decarbonisation targets, and regain competitiveness.

The analysis examines five core heat pump components, namely compressors, heat exchange units (HEU), fans, controllers, and refrigerants, across four dimensions: production levels, international competitiveness, trade balances and import dependencies, and innovation capacities. It draws on disaggregated trade and production data, desk research, and interviews with nine industry stakeholders and experts, benchmarking the EU against China, the US, and Japan.

Four key findings emerge:

First, EU production is highest for HEUs and compressors and remains concentrated in large Western European economies, although Central and Eastern European countries are playing a growing role.

Second, HEUs have the strongest and most solid export profile. However, the EU as a whole faces intensifying cost-based competition, particularly from China, which is also upgrading to higher-value segments.

Third, the EU is competitive for several components and particularly strong for HEUs but remains dependent on imports for compressors and certain refrigerants.

Fourth, innovation across the value chain is largely incremental, reflecting the maturity of the underlying technologies. The EU holds a leading innovation position for HEUs, while compressors are its weakest area, with intellectual property concentrated in Japan and the USA. Regulatory pressure, particularly around the shift to natural refrigerants, is a strong and distinctive driver of EU innovation.

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