SMEs and Open Strategic Autonomy

Final Report

Annex V - Ecosystem analysis

Written by: CSIL, IDEA Consult, PPMI, LSE – Trade Policy Hub
3 July 2024

Directorate-General for Internal market, Industry, Entrepreneurship and SMEs
Single Market Programme - SME Pillar

EUROPEAN COMMISSION

Directorate-General for Internal market, Industry, Entrepreneurship and SMEs
Directorate A – Strategy and Economic Analysis
Unit A.2 – SMEs
E-mail: GROW-SPR@ec.europa.eu
European Commission
B-1049 Brussels

SMEs and Open Strategic Autonomy

Final Report

Annex V - Ecosystems analysis

Directorate-General for Internal market, Industry, Entrepreneurship and SMEs
Single Market Programme - SME Pillar

Main authors of this deliverables: Sara Banfi (CSIL), Giulia Canzian (CSIL), Francesco Giffoni (CSIL), Kris Boschmans (IDEA Consult), Valentijn Bilsen (IDEA Consult), Marco Schito (PPMI), Luka Klimavičiūtė (PPMI), Elitsa Garnizova (Trade Policy Hub, LSE Consulting), Apoorva Vishnoi (Trade Policy Hub, LSE Consulting). Emanuela Sirtori (CSIL) for quality review.

PDF	ISBN 978-92-68-18114-0	doi: 10.2873/45743	ET-09-24-498-EN-N

Manuscript completed in July 2024

Luxembourg: Publications Office of the European Union, 2024

Table of contents

List of figures

List of tables

List of boxes

Foreword

The European Commission has entrusted CSIL, in collaboration with IDEA Consult, PPMI, and LSE, to conduct a comprehensive study on "SMEs and Open Strategic Autonomy."

This Annex, accompanying the study's Final Report, presents a comprehensive analysis of ecosystems. It is based on desk research and 103 interviews with different stakeholders, including EU policymakers, Member State representatives, business associations, SMEs, research organisations, and experts.

1 OSA and SMEs in the access to raw materials

Highlights:

- The Green and Digital transition is leading to a steady increase in the demand for raw materials worldwide, resulting in supply shortages, with the EU heavily reliant on external sources due to limited extracting and mining capacity.
- SMEs are actively involved in the extraction industry, participating in several stages of the value chain. They dominate the industrial mineral mining industry, representing 80% of all participants. In the extraction of metal raw materials, SMEs focus on the less capital-intensive segments: they are engaged in the exploration phase and play significant roles downstream as manufacturers and in the recycling process.
- Raw materials shortages impact all types of firms in Europe across various ecosystems, with the potential for significant effects on SMEs due to their limited bargaining power in accessing alternative sources.
- Some OSA policies in this domain have already been implemented at the EU and MS levels, aiming to increase domestic extraction/production of certain materials while securing access to others through supply diversification.
- The EU has recognised the importance of recovering critical materials from discarded products, waste, and infrastructure as a viable solution to overcome limited extraction potential in the EU. This activity would offer significant business opportunities for SMEs.

1.1 The use of raw materials across ecosystems and strategic vulnerabilities

This section addresses the concept of strategic autonomy in access to raw materials. The general considerations are presented here because raw materials are crucial across various ecosystems. More nuanced and specific details are provided in ecosystem-specific sections throughout this report.

The EU currently plays a minor role in the production of critical raw materials, both in terms of extraction and processing. Over the past decades, a general lack of investment in geological exploration using advanced technologies by EU Member States has resulted in limited knowledge about the true potential of critical raw materials within the EU. This scarcity of information hinders further exploration and exploitation by private companies at sites of mining interest. Moreover, before establishing a common framework, the EU's capability to enhance its extraction, processing, or recycling capacities remains underutilized. Additionally, the existing knowledge of mineral deposits in Member States is often outdated, dating from a time when these materials were not as highly valued as they are today.

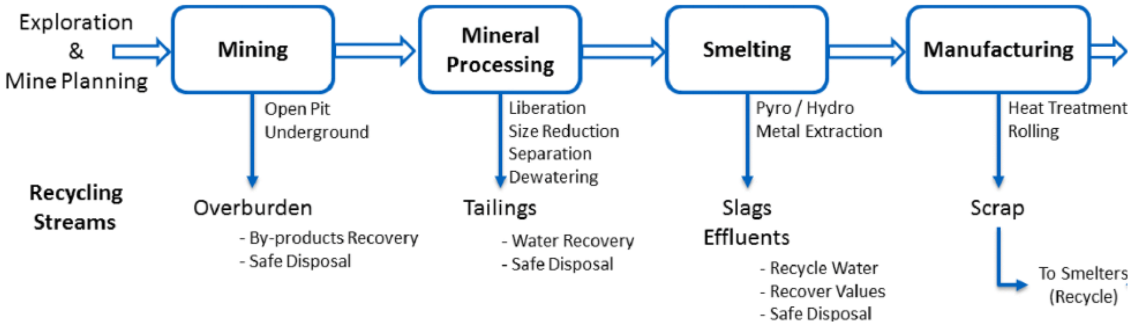
The **metal extraction industry** is structured into five main stages: i) exploration; ii) extraction/ mining; ii) processing/refining; iv) manufacturing; vi) recycling. **While the extraction and processing stages are typically dominated by large companies, other stages predominantly involve SMEs**. Extraction is a capital-intensive and risky activity with uncertainties surrounding the ore quality, cost increases, market volatility, and problems with permitting or social resistance can still lead projects to fail. Such activities demand substantial initial investments, typically only manageable by investment funds or very large companies. For instance, a stakeholder mentioned an initial investment of EUR 2 billion required for a magnesium mining project in Europe. Processing also demands significant investments for energy-intensive operations and the setup of specialized industrial plants, which additionally require various permits.

In contrast, SMEs play a significant role in the early stages of the value chain, which require fewer resources and capacities to undertake the risk-heavy exploration operations. While not the most capital-intensive, the exploration stage is characterised by high risk, as only a fraction of exploration ventures lead to successful mining projects. Most often, players active in this sector are SMEs. They mainly operate as junior companies, which often focus on a single project without operating revenue and rely on equity financing. SMEs are also prevalent in the manufacturing stage, where they extensively use these metals. In the recycling phase, although SMEs are excluded from energy-intensive smelting operations, they are actively involved in collection and, depending on the waste stream, in sorting and removing hazardous materials.[1]

Box 1: The supply chain of the metal extraction industry

1. **Exploration**. It consists in identifying a deposit of a certain mineral or metal and ascertaining that it is technically and economically recoverable.
2. **Mining**, or **Extraction**. The development of the actual mine and of the surrounding infrastructure, as well as its operation. It entails the permitting process, environmental impact assessments, and feasibility studies.
3. **Processing stage**. It may be located on the same site as the mine or elsewhere, depending on the mineral and the site's specificities. The ore that has been extracted at the mining stage is beneficiated, i.e. separated from economically worthless material, through crushing, roasting, magnetic separation, flotation or leaching, to get an ore concentrate. A second step in getting from ore to metal, sometimes included under the heading of processing, is the smelting or refining step.
4. **Manufacturing stage**. It depends very much on the application (from steel and alloying plants to chemical operations, battery manufacturing and many more).
5. **Recycling stage**. After collection and, depending on the waste stream, sorting and removal of hazardous waste, material recycling is done in smelting plants, sometimes in specialized recycling smelting plants, sometimes through mixing of primary and secondary inputs.

Figure 1. Metal extraction value chain



[1] European Commission (2023). Impact assessment report accompanying the document Proposal for a Regulation of the European Parliament and of the Council establishing a framework for ensuring a secure and sustainable supply of critical raw materials and amending Regulations (EU) 168/2013, (EU) 2018/858, 2018/1724 and (EU) 2019/1020. SWD(2023) 161 final. Annex 10, Annex 6

Source: European Commision (2023)

Source: Authors

The **mineral industry**, which includes minerals like borates and feldspar and requires lower investments and technical expertise, **is dominated by SMEs**. Stakeholders interviewed indicate that SMEs represent approximately 80% of the companies active in the extraction and processing phases, which the same company typically manages. Conversely, large companies, often comprising small local subsidiaries, contribute the most to industry turnover.

Although most critical raw materials (CRMs) are metals and theoretically highly recyclable, the actual rate of recycling remains low. This is due to a combination of factors. They are often used in low concentrations within alloys or other mixtures, making their recovery from end-of-life products both technically challenging and economically unfeasible. Historically, many CRMs have not been used extensively, as their major markets, such as renewable energies, electric mobility, and digital technologies, have only recently begun to grow rapidly. Additionally, these materials are typically incorporated into products with long lifespans, such as wind turbines, which can last 20 years or more.

Due to these conditions, the limited quantities recovered do not warrant the substantial investments required to develop targeted recycling processes or to establish and operate industrial-scale recycling facilities. Consequently, CRMs are often discarded at the end of a product's life or recycled in a manner that does not utilize their unique properties. Furthermore, current recycling practices and waste legislation primarily emphasize waste collection and depollution, along with the overall recovery of mass. Still, they inadequately address the retrieval of trace metals like CRMs.

As a result, **all types of businesses that rely on raw materials are strategically affected by the dependencies on external supply**. This **exposure is associated with multiple risks**:[2]

- **Risk of geopolitical vulnerability**: If geopolitical conflicts arise, these essential materials might be restricted from being exported to the EU. This could cause shortages and significant price increases, potentially disrupting the European economy.
- **Risk of adverse environmental and social effects**: The extraction, processing, and waste treatment of critical raw materials can harm the environment and local communities, particularly in countries with relatively low levels of governance. If left unmitigated, these issues could undermine both EU and global efforts to transition to an environmentally sustainable and climate-neutral economy.
- **Risk of unforeseen disruptions to industrial supply chains**: the supply of critical raw materials is particularly rigid in the short term. CRM supplies are particularly rigid and highly concentrated in a few regions. Therefore, political instability, trade disputes, or natural disasters could cause simultaneous disruptions in major production sites, thus leading to shortages, which can only be addressed by price spikes shedding demand and thereby affecting major downstream industries.
- **Risk of high and volatile prices delaying the green transition**: A structural shortage of critical raw materials and growing uncertainty could lead to rising and fluctuating

[2] European Commission (2023). Impact assessment report accompanying the document Proposal for a Regulation of the European Parliament and of the Council establishing a framework for ensuring a secure and sustainable supply of critical raw materials and amending Regulations (EU) 168/2013, (EU) 2018/858, 2018/1724 and (EU) 2019/1020. SWD(2023) 161 final. Annex 10

prices. These price increases could disrupt planned clean energy projects and make it more challenging and expensive for the EU to meet its climate and renewable energy goals.

During interviews, stakeholders concurred that **these risks disproportionately affect SMEs**. Larger firms possess greater financial flexibility and more control over their supply chains. Conversely, SMEs, particularly those active in manufacturing sectors that depend on raw materials, are more vulnerable to sudden or long-term shortages. They are less likely to already have contingency measures in place, and they lack significant bargaining power regarding price, delivery times, and overall access. However, this lack of bargaining power may prompt SMEs to seek alternative solutions. They could play a key role in encouraging the recycling of raw materials from discarded products, an area less appealing to larger companies. Additionally, SMEs might lead the way in investing in innovation to make the use of raw materials more efficient and sustainable.

The EU heavily relies on various critical raw materials essential for various industries, from rare earth elements to metals such as lithium and cobalt. These materials serve as fundamental components in manufacturing processes and driving technological advancements. For example, rare earths and borates are indispensable in producing electric cars and wind turbines. Similarly, platinum group metals are vital for hydrogen fuel cells and digital technologies (Table 1). As Europe advances towards climate-neutral practices, there is an increasing necessity to substitute fossil fuels and focus on renewable energy technologies and energy efficiency. This shift increases the demand for and dependency on non-energy raw materials. The **EU faces critical vulnerabilities in raw materials**, which can be summarised as follows:

- **Global competition**: Intense global competition exposes EU industries to risks of supply shortages and price fluctuations in raw material markets. As the world increasingly turns to renewable energy and digitalizes its economies and societies, the demand for certain critical raw materials is expected to rise significantly in the coming decades. For instance, the global demand for lithium, essential for manufacturing batteries for mobility and energy storage, is expected to increase by up to 89 times by 2050.[3]
- **Concentration of supply**: Material extraction has doubled since 1990. Against this trend, the supply of 30 critical raw materials identified by the EU is highly concentrated in a few countries worldwide, increasing vulnerability to supply disruptions. For example, the EU sources 97% of its magnesium in China. Heavy rare earth elements, used in permanent magnets, are exclusively refined in China. 63% of the world's cobalt, used in batteries, is extracted in the Democratic Republic of Congo, while 60% is refined in China. In addition, EU supply is more concentrated than global supply (for bauxite, borate or manganese). This concentration expands along the value chain, with the processing stage being even more concentrated than the extraction stage for some materials, such as lithium, magnesium, or germanium.[4]
- **Heavy dependence on imports**: The EU relies heavily on imported raw materials for key products and technologies and contributes only a small fraction of global production. It is, therefore, increasingly susceptible to supply disruptions. Potential

[3] European Commission (2023). Proposal for a regulation of the European Parliament and of the Council establishing a framework for ensuring a secure and sustainable supply of critical raw materials and amending Regulations (EU) 168/2013, (EU) 2018/858, 2018/1724 and (EU) 2019/1020. COM(2023) 160 final

[4] European Commission (2023). Proposal for a regulation of the European Parliament and of the Council establishing a framework for ensuring a secure and sustainable supply of critical raw materials and amending Regulations (EU) 168/2013, (EU) 2018/858, 2018/1724 and (EU) 2019/1020. COM(2023) 160 final

export restrictions by supplier countries could further strain EU raw material supply chains, leading to supply shortages and increased competition for limited resources.

- **Rising demand**: Increasing demand for critical raw materials across various sectors and technologies, including renewables, e-mobility, defence, aerospace, and digitalisation, exacerbates supply chain vulnerabilities. In this respect, semiconductors are particularly critical, given the worldwide supply shortage since late 2020 and the demand for electronic controls for all other sectors, from e-mobility to space. For example, EU demand for rare earth elements, used in making permanent magnets for wind turbines and electric vehicles, is expected to grow six to seven times by the same year. EU demand for gallium, crucial for semiconductor production, is projected to increase 17 times by 2050.[5]
- **Intersectoral competition**: Different industries may compete for access to the same resources in limited raw material availability scenarios, exacerbating supply chain constraints. For example, hydrogen is used in direct reduced iron technology for steel production and fuel cell production for mobility industries, leading to potential competition for this critical resource. REEs, silicon and cobalt are crucial for the production of generators in wind turbines and electric motors, solar PV panels, and high-energy density Lithium-ion EV batteries, respectively.

As shown in Figure 2, China dominates several raw materials extraction and refinement process. Europe has relatively higher shares in the extraction of silica materials (quartz and sand), zinc, and silver and the refinement of cobalt, silicon, zinc, lead, copper, and nickel.

Table 1. Use and production of critical raw materials.

Raw materials	Used for	Main Production (extraction and refinement) areas (2022)
Gallium	Solar energy technologies; Robotics; Drones; Space Systems; Telecommunications; Microelectronics; AI, Cybersecurity; Cloud and Edge Computing	China, Russia, Ukraine, Japan, South Korea
Magnesium	Electrolysers; Robotics; Drones; Space Systems; Microelectronics; AI, Cybersecurity; Cloud and Edge Computing	China, USA, Israel, Brazil, Russia, Kazakhstan, Turkey
Rare-Earth Elements (REE) - magnets	Fuel cells; Electrolysers; Wind energy technologies (turbines); Heat pumps; Robotics; Drones; Space Systems; Telecommunications; Microelectronics; AI, Cybersecurity; Cloud and Edge Computing	China, East Asia, USA
Boron	Fuel cells; Electrolysers; Wind energy technologies (turbines); Solar energy technologies; Heat pumps; Robotics; Drones; Space Systems; Telecommunications; Microelectronics; AI, Cybersecurity; Cloud and Edge Computing	Extraction: Middle-East (Turkey) Refinement: China
Platinum-group metals (PGM)	Fuel cells; Electrolysers; Robotics; Drones; Space Systems; Telecommunications; Microelectronics; AI, Cybersecurity; Cloud and Edge Computing	South Africa, Russia, Sub-Saharan Africa (Zimbabwe), Canada, USA
Lithium	Li-ion batteries; Robotics; Drones; Space Systems; Telecommunications; Microelectronics; Chemical fertilisers	Latin America (Chile), Oceania (Australia), China

[5] European Commission (2023). Proposal for a regulation of the European Parliament and of the Council establishing a framework for ensuring a secure and sustainable supply of critical raw materials and amending Regulations (EU) 168/2013, (EU) 2018/858, 2018/1724 and (EU) 2019/1020. COM(2023) 160 final

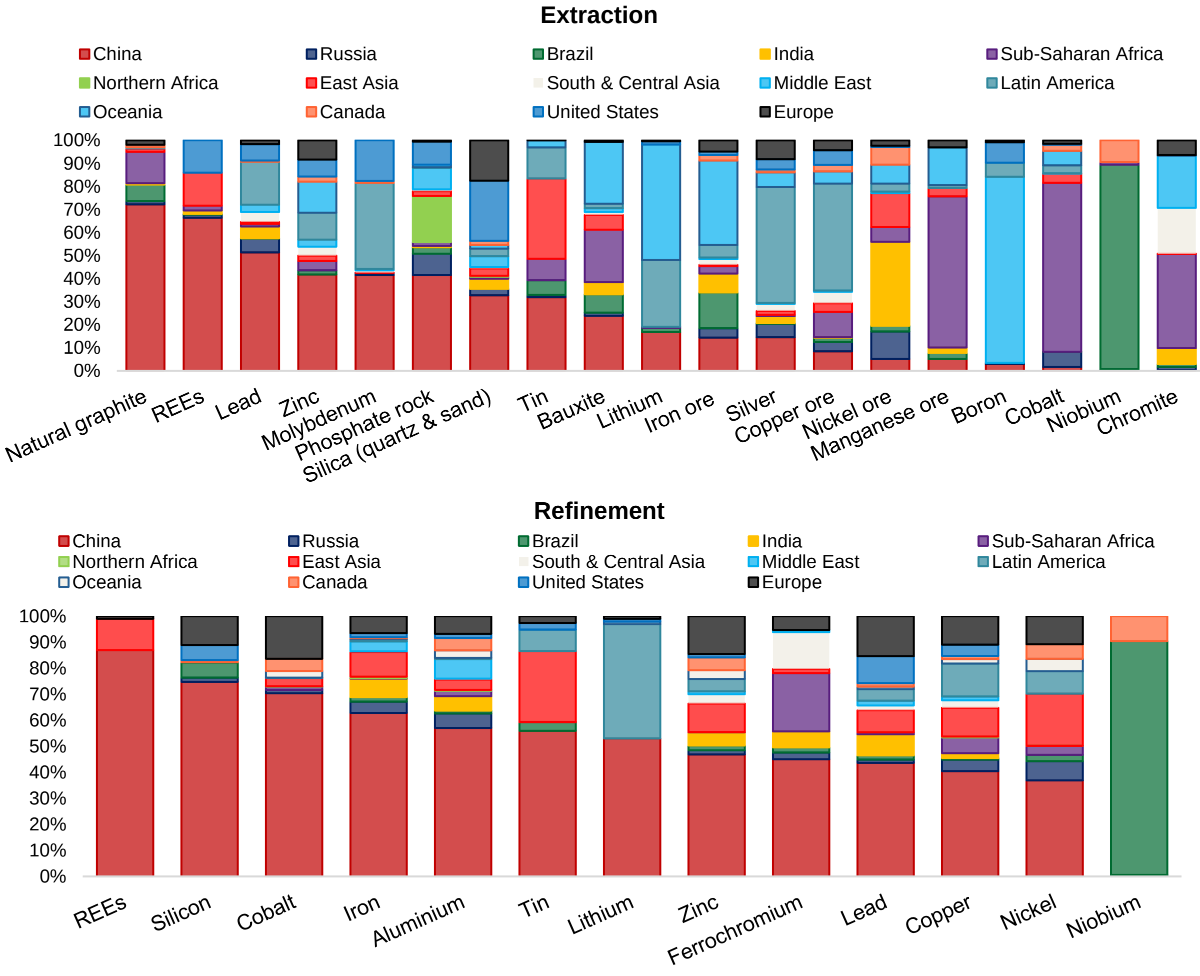
Raw materials	Used for	Main Production (extraction and refinement) areas (2022)
Bismuth	Space Systems; Telecommunications; Microelectronics; AI, Cybersecurity; Cloud and Edge Computing	China, Mexico, Latin America (Peru and Bolivia)
Germanium	Solar energy technologies; Space Systems; Telecommunications; Microelectronics; AI, Cybersecurity; Cloud and Edge Computing	China, Canada, Finland, Russia, USA.
Natural graphite	Li-ion batteries; Fuel cells; Electrolysers; Robotics; Drones; Telecommunications; Microelectronics	China, Sub-Saharan Africa (Madagascar, Mozambique), Brazil, South Korea
Cobalt	Li-ion batteries; Fuel cells; Electrolysers; Robotics; Drones; Space Systems; Telecommunications; Microelectronics	Sub-Saharan Africa (Rep. of Congo), Oceania (Indonesia, Australia), Russia
Titanium metal	Robotics; Drones; Space Systems	China, Japan, Russia, Saudi Arabia
Silicon metal	Fuel cells; Electrolysers; Wind energy technologies (turbines); Solar energy technologies; Heat pumps; Robotics; Drones; Space Systems; Telecommunication; Microelectronics; AI, Cybersecurity; Cloud and Edge Computing	China, Russia, Latin America (Brazil), Norway, USA
Tungsten	Electrolysers; Drones; Space Systems; Microelectronics	North Korea, Europe (Spain, Portugal, UK, Austria)
Manganese	Li-ion batteries; Fuel cells; Electrolysers; Wind energy technologies (turbines); Heat pumps; Robotics; Drones; Space Systems; Telecommunications; Microelectronics; AI, Cybersecurity; Cloud and Edge Computing	South Africa, Sub-saharan Africa (Gabon, Ghana), Oceania (Australia), China, India
Nickel	Li-ion batteries; Fuel cells; Electrolysers; Wind energy technologies (turbines); Solar energy technologies; Heat pumps; Robotics; Drones; Space Systems; Telecommunications; Microelectronics; AI, Cybersecurity; Cloud and Edge Computing	Oceania (Indonesia, New Caledonia, Australia), Philippines, Russia, Canada
Copper	Li-ion batteries; Fuel cells; Electrolysers; Wind energy technologies (turbines); Solar energy technologies; Heat pumps; Robotics; Drones; Space Systems; Microelectronics; AI, Cybersecurity; Cloud and Edge Computing	Latin America (Chile, Peru), Sub-Saharan Africa (Rep. of Congo, Zambia), China, USA, Russia
Heavy Rare-Earth Elements - especially dysprosium and terbium	Fuel cells; Electrolysers; Robotics; Drones; Space Systems; Telecommunications; Microelectronics; AI, Cybersecurity; Cloud and Edge Computing	China, Vietnam, Latin America (Brazil), Russia, India, Australia, USA
Niobium	Electrolysers; Wind energy technologies (turbines); Drones; Space Systems; Telecommunications; Microelectronics	Latin America (Brazil), Canada, Sub-Saharan Africa (Angola), Oceania (Australia), China
Light Rare-Earth Element - especially, lanthanum, cerium, praseodymium, neodymium, samarium, europium	Fuel cells; Electrolysers; Robotics; Drones; Space Systems; Telecommunications;	Depending on the element: Latin America (Brazil), India, Oceania (Australia), South Africa), China, Russia

Raw materials	Used for	Main Production (extraction and refinement) areas (2022)
Phosphorus	Li-ion batteries; Solar energy technologies; Space Systems; Microelectronics; AI, Cybersecurity; Cloud and Edge Computing	North Africa (Morocco), USA, China
Strontium	Fuel cells; Electrolysers; Telecommunications; Microelectronics	China, Europe (Spain), Mexico, Latin America (Argentina), North Africa (Morocco)
Scandium	Electrolysers; Space Systems; AI, Cybersecurity; Cloud and Edge Computing	Ukraine, China, Russia
Vanadium	Fuel cells; Electrolysers; Robotics; Drones; Space Systems; Telecommunications;	China, South Africa, Russia
Antimony	Solar energy technologies Robotics; Drones; Space Systems; Telecommunications; Microelectronics; AI, Cybersecurity; Cloud and Edge Computing	China, Russia, Tajikistan.
Beryllium	Space Systems; Microelectronics; AI, Cybersecurity; Cloud and Edge Computing	USA, Kazakhstan, China
Arsenic	Solar energy technologies; Space Systems; Telecommunications; Microelectronics; AI, Cybersecurity; Cloud and Edge Computing	China Latin America (Peru), Philippines
Feldspar	Fuel cells; Drones; Microelectronics; AI, Cybersecurity; Cloud and Edge Computing	USA, Turkey, Europe (Germany, Italy)
Hafnium	Drones; Space Systems;	Europe (France), USA
Baryte	Fuel cells; Electrolysers; Space Systems; Telecommunications; Microelectronics; AI, Cybersecurity; Cloud and Edge Computing	Oceania (Australia), China, Sub-Saharan Africa (Guinea), Latin America (Brazil), India
Tantalum	Electrolysers; Drones; Space Systems; Telecommunications; Microelectronics	Sub-Saharan Africa (Rep. of Congo, Rwanda, Ethiopia, Mozambique), Latin America (Colombia, Brazil), Oceania (Australia), China
Aluminium	Li-ion batteries; Fuel cells; Electrolysers; Wind energy technologies (turbines); Solar energy technologies; Heat pumps; Robotics; Drones; Space Systems; Telecommunications; Microelectronics; AI, Cybersecurity; Cloud and Edge Computing	China, Russia, India, Canada, the Middle East (UAE, Bahrain), Oceania (Australia), and Europe (Norway).
Helium	Space Systems; AI, Cybersecurity; Cloud and Edge Computing	USA, Middle-East (Qatar)
Fluorspar	Li-ion batteries; Solar energy technologies; Heat pumps; Robotics; Drones; Space Systems; Telecommunications; Microelectronics	China, Mexico, Mongolia, Vietnam, South Africa
Phosphate rock	Telecommunications	China, North Africa, Russia, USA

Source: Authors based on JRC (2023)[6] and Statista Data (Chemicals & Resources› Mining, Metals & Minerals, see https://www.statista.com/statistics/270277/mining-of-rare-earths-by-country/).

[6] JRC (2023). Supply chain analysis and material demand forecast in strategic technologies and sectors in the EU – A foresight study. doi:10.2760/334074

Figure 2. Regions of extraction and refinement of renewable energy minerals (2020)



Source: Bruegel based on US Geological Survey

Box 2: Dependencies on raw materials available in Europe: the case of feldspar

Feldspars is not a scarce resource. It constitutes approximately about 60% of the Earth's crust,[7] and it is largely available in European soil. Nevertheless, according to stakeholders interviewed, **nearly half of the feldspar used in Europe is imported from Turkey.** Many European companies involved in the extraction and processing of this raw material opt to relocate their operations to Turkey. This decision is influenced by various factors in the business environment, notably the lower costs of energy and labour, as well as the greater logistical and transportation support provided by Turkish authorities. Additionally, obtaining permits appears to be more efficient in Turkey, with interviewees indicating that it takes over ten years to obtain a permit in Europe compared to 2-3 years in Turkey. Consequently, **this current trend seems to lead towards reduced autonomy rather than increased autonomy.**

Source: Authors

[7] Neuendorf, K.K.E.; Mehl, J.P. Jr.; Jackson, J.A., eds. (2005). Glossary of Geology (5th ed.). Alexandria, Virginia: American Geological Institute. p. 232. ISBN 978-0922152896.

1.2 OSA goals and overview of relevant policy measures

Recognising the vulnerability posed by dependency on external suppliers, especially in increasing demand, the EU has set strategic goals to enhance its resilience. Key objectives include:

- **increasing domestic production** of some raw materials;
- securing access to critical raw materials by **diversifying sourcing locations** to reduce geopolitical risks;
- **increasing the supply of materials from recovery and recycling** of products at the end of their life;
- implementing measures to **mitigate potential cost increases** during emergencies.

The map in Figure 3 shows the location of mining activities in the EU. According to the latest edition of the EU Raw Materials Scoreboard (2021), **as many as 13 new mining activities** (highlighted with a black border line) **have been identified since 2017**. Following the increasing global demand for lithium for batteries, four EU lithium projects in the exploration stage in 2017 have become active mines. The EU is also coordinating efforts to increase magnesium extraction in Europe (currently concentrated in Germany, France and Austria) due to the 2021 supply constraints.

Compared to the situation depicted in the 2018 Scoreboard, some mineral exploration projects have progressed towards more advanced stages, with some even starting production. However, the EU's mineral potential remains under-explored, and **the budget allocated for exploring metallic minerals in the EU remains low compared to other regions globally.** In this respect, there are notable differences in the exploration activity among Member States. Mineral exploration activities in 2019 were primarily concentrated in Ireland, Spain, Portugal, Sweden, and Finland, which are considered attractive for investment in exploration. Gold, copper, and zinc remain the primary target commodities.

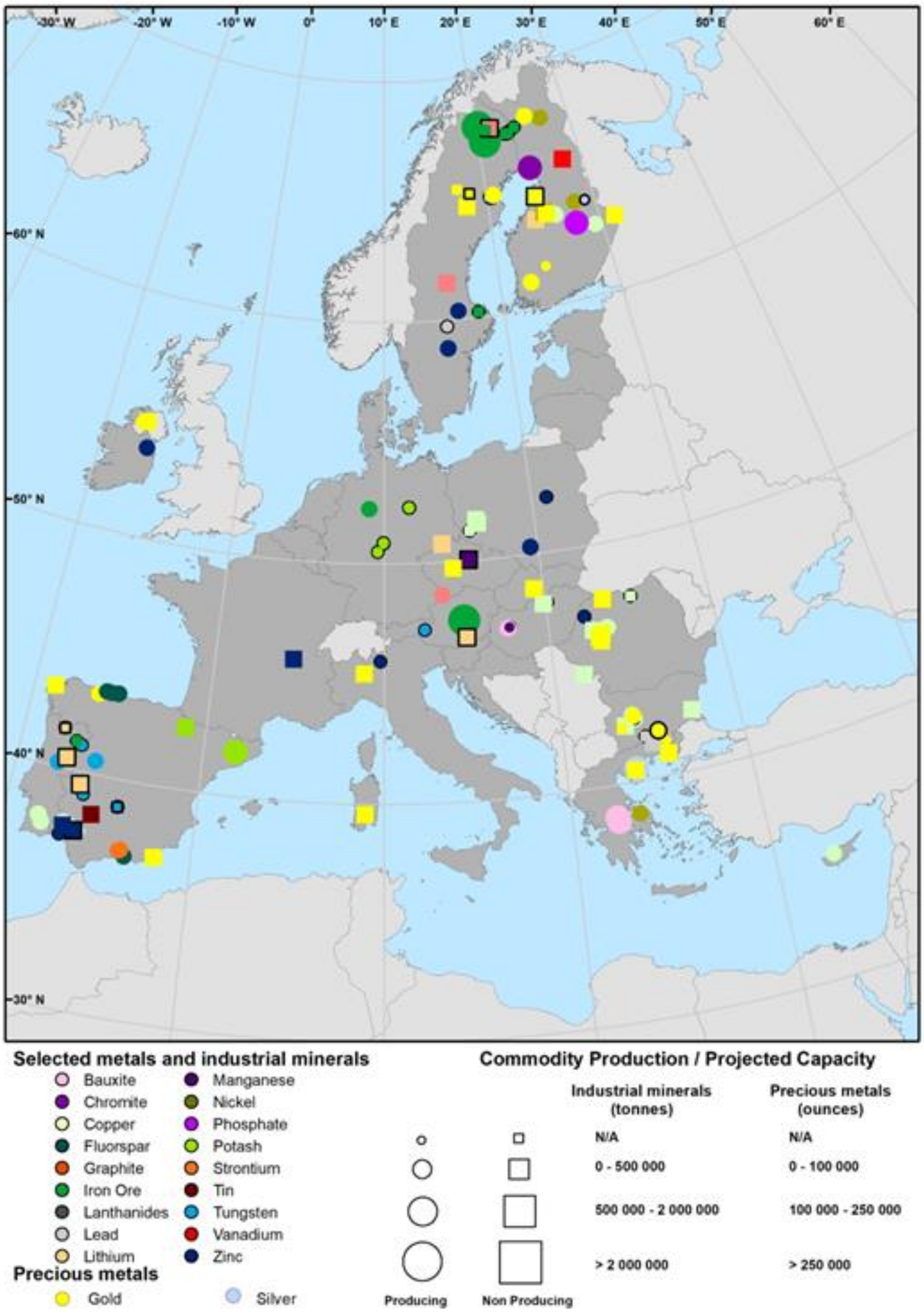
Overall, the EU is currently underutilizing its domestic potential for critical raw materials. Mineral prices and future metal demand primarily drive exploration activities, but investment in mining projects is inherently long-term and requires substantial capital. Additionally, **several challenges hinder investment in exploration activities** in the EU, including insufficient exploration of European mineral resources, unpredictable and fragmented permitting procedures, difficulty in accessing financing, lack of CRM-related skills and expertise, EU waste legislation does not sufficiently target critical raw materials recovery, lack of high-quality technical standards for critical raw materials-related industrial processes, lack of public acceptance for critical raw materials mining in Europe.[8] Altogether, these challenges limit the possibility of increasing domestic production of critical raw materials.

Over the years, various high-level initiatives have been launched to advance the framework for enhancing OSA in raw materials. The European Commission's "Raw Materials Initiative" and its subsequent "Raw Materials Supply Group" provide frameworks for securing access, diversifying sources, and mitigating cost increases during emergencies.[9] Additionally, the "EU Critical Raw Materials List" identifies materials deemed essential for the EU's economy and

[8] European Commission (2023). Impact assessment report accompanying the document Proposal for a Regulation of the European Parliament and of the Council establishing a framework for ensuring a secure and sustainable supply of critical raw materials and amending Regulations (EU) 168/2013, (EU) 2018/858, 2018/1724 and (EU) 2019/1020. SWD(2023) 161 final.

[9] European Commission. (2008). Communication from the Commission to the European Parliament and the Council: The Raw Materials Initiative – Meeting Our Critical Needs for Growth and Jobs in Europe. COM(2008) 699 final. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52008DC0699.

Figure 3. Mine production of metal and selected industrial minerals in the EU-27 (2019)



Note: New projects are indicated by circle points (active, producing) and squares (active, non-producing) with a black border line.
Source: European Commission Raw Materials Scoreboard (2021) https://rmis.jrc.ec.europa.eu/scoreboard2021#/

outlines strategies for their sustainable management and supply.[10] The "EU Green Deal" and "Circular Economy Action Plan" further emphasise the importance of sustainable extraction

[10] European Commission. (2020). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Critical Raw Materials Resilience: Charting a Path towards

practices and recycling initiatives to reduce dependency and enhance resilience.[11] Furthermore, studies by the European Parliamentary Research Service and the European Strategy Forum on Research Infrastructures provide insights into the challenges and opportunities associated with the EU's raw materials strategy, guiding policymakers to strengthen the EU's resilience.[12,13]

The EU has identified recycling and material substitution as a viable solution to overcome limited extraction activity. The notion of “urban mining” is often used to refer to the vast reservoirs of recyclable materials and valuable resources that exist within urban environments, primarily in the form of discarded products, waste, and infrastructure. These materials represent potential sources of secondary raw materials that can be extracted, processed, and reused rather than disposed of as waste. This approach aligns with the EU’s raw materials initiative and circular economy action plan. However, recycling’s contribution to meeting demand is still generally low, with secondary materials only approaching or surpassing one-third of current demand in a few cases, such as rhenium, tungsten, iron, tin, and zinc. Lead is the only material where secondary materials exceed 50% of current demand.

Box 3: Recovery of raw materials from other products: examples from batteries and fuel cells

Rare earth magnets and motors are essential components in battery and fuel cell electric vehicles. The 2023 Regulation on batteries and waste batteries represents a significant step towards promoting sustainable practices in the battery industry. This regulation introduces mandatory recycling quotas to enhance the circularity of battery materials and reduce reliance on primary raw materials, particularly critical raw materials such as cobalt, lithium and nickel.[14] In 2018, a CEPS study estimated that from EUR 400 to 550 million in **cobalt, nickel, aluminium, and lithium** could be recovered by electric vehicle batteries by 2030. This value could reach EUR 1.9-2.6 billion by 2040.[15] **Platinum group metals** (PGMs) – i.e. platinum, palladium, and rhodium – are highly recyclable and once recycled, secondary PGMs have the same properties as primary PGMs. The largest source of secondary supply today is catalytic converters. Organisations like the International Platinum Group Metals Association play a significant role in overseeing and facilitating the recovery process of these precious metals from spent fuel cells. Most PGMs are recoverable throughout the product lifecycle, from production scrap to end-of-life materials.[16]

Greater Security and Sustainability. COM(2020) 474 final. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0474.

[11] European Commission. (2019a). Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee, and the Committee of the Regions: The European Green Deal. COM(2019) 640 final. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52019DC0640.
European Commission. (2020b). Communication from the Commission to the European Parliament, the European Council, the European Economic and Social Committee and the Committee of the Regions: A New Circular Economy Action Plan for a Cleaner and More Competitive Europe. COM(2020) 98 final. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0098.

[12] European Parliamentary Research Service. (2017). EU Raw Materials Policies and Resource Strategies: Challenges and Opportunities. Retrieved from https://www.europarl.europa.eu/RegData/etudes/STUD/2017/581470/IPOL_STU(2017)581470_EN.pdf.

[13] European Strategy Forum on Research Infrastructures. (2021). European Research Infrastructures for the Development of Technologies and Systems for Renewable Energy Sources, Energy Storage, Transmission and Distribution. Retrieved from https://www.esfri.eu/sites/default/files/ERIforESS%20white%20paper%20%28final%29.pdf.

[14] REGULATION (EU) 2023/1542 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 12 July 2023 concerning batteries and waste batteries, amending Directive 2008/98/EC and Regulation (EU) 2019/1020 and repealing Directive 2006/66/EC.

[15] CEPS (2018) “Prospects for electric vehicle batteries in a circular economy”, Research report 2018/05. https://circulareconomy.europa.eu/platform/sites/default/files/circular_economy_impacts_batteries_for_evs.pdf

[16] Johnson Matthey, « A guide to PGMs. Understanding the fundamentals of platinum group metals » ghttps://matthey.com/documents/161599/404086/7843_JMP_PGM_Guide_3_v2.pdf/82c84aa8-5c32-2dbc-f47d-c1752a500989?t=1707173188044

Source: Authors

Several factors limit the availability of secondary materials, including economic or technical feasibility, collection rates, product lifetime and losses in manufacturing or use.

In 2021, the European Raw Materials Alliance (ERMA) identified investment cases from rare earth mines and urban mines, with projects spread across Europe and a total investment volume of EUR 1.7 billion. These initiatives have the potential to fulfil approximately 20% of Europe's demand for rare earth magnets by the year 2030, which is 15 times more than today.[17][18] Furthermore, the EU collaborates with international partners through alliances and networks focused on critical raw materials. These initiatives aim to enhance cooperation in raw materials exploration, processing, recycling, and supply chain management to address global challenges related to critical raw materials.

In March 2024, the Council adopted the "European Critical Raw Materials Act,"[19] a **comprehensive framework designed to secure the EU's access to a reliable, diversified, affordable, and sustainable supply of critical raw materials**. This initiative includes a Regulation and a Communication. The Regulation establishes a regulatory framework that supports the development of domestic capacities and enhances the sustainability and circularity of critical raw material supply chains within the EU. The Communication outlines measures to diversify supply chains through new international partnerships that are mutually beneficial. Additionally, it focuses on maximizing the benefits of EU trade agreements in alignment with the Global Gateway strategy, ensuring a cohesive approach to global trade and cooperation.

Box 4: The European Critical Raw Materials Act - Regulation

The Critical Raw Materials Act will equip the EU with the tools to ensure the EU's access to a secure and sustainable supply of critical raw materials, mainly through:

- **Setting clear priorities for action**: In addition to an updated list of critical raw materials, the Act identifies a list of strategic raw materials, which are crucial to technologies important to Europe's green and digital ambitions and for defence and space applications, while being subject to potential supply risks in the future. The Regulation embeds both the critical and strategic raw materials lists in EU law. The Regulation sets clear benchmarks for domestic capacities along the strategic raw material supply chain and to diversify EU supply by 2030:
    - At least 10% of the EU's annual consumption for extraction,
    - At least 40% of the EU's annual consumption for processing,
    - At least 15% of the EU's annual consumption for recycling,
    - Not more than 65% of the Union's annual consumption of each strategic raw material at any relevant stage of processing from a single third country.
- **Creating secure and resilient EU critical raw materials supply chains**: The Act will reduce the administrative burden and simplify permitting procedures for critical raw materials projects in the EU. In addition, selected Strategic Projects will benefit from

[17] ERMA (2021) « Rare Earth Magnets and Motors: A European Call for Action » A report by the Rare Earth Magnets and Motors Cluster of the European Raw Materials Alliance. Berlin 2021

[18] Commission staff working document EU strategic dependencies and capacities: second stage of in-depth reviews, SWD(2022) 41 final, EU Commission, 22,02,2022. p.29.

[19] European Commission (2023). Proposal for a regulation of the European Parliament and of the Council establishing a framework for ensuring a secure and sustainable supply of critical raw materials and amending Regulations (EU) 168/2013, (EU) 2018/858, 2018/1724 and (EU) 2019/102. Retrieved from: https://single-market-economy.ec.europa.eu/publications/european-critical-raw-materials-act_en

support for access to finance and shorter permitting timeframes (24 months for extraction permits and 12 months for processing and recycling permits). Member States will also have to develop national programmes to explore geological resources.

- **Ensuring that the EU can mitigate supply risks**: To ensure the resilience of the supply chains, the Act provides for the monitoring of critical raw materials supply chains, and the coordination of strategic raw materials stocks among Member States. Certain large companies will have to perform an audit of their strategic raw materials supply chains, comprising a company-level stress test.
- **Investing in research, innovation and skills**: The Commission will strengthen the uptake and deployment of breakthrough technologies in critical raw materials. Furthermore, the establishment of a large-scale skills partnership on critical raw materials and a Raw Materials Academy will promote skills relevant to the workforce in critical raw materials supply chains. Externally, the Global Gateway will be used as a vehicle to assist partner countries in developing their own extraction and processing capacities, including skills development.
- **Protecting the environment by improving circularity and sustainability of critical raw materials**: Improved security and affordability of critical raw materials supplies must go hand in hand with increased efforts to mitigate any adverse impacts, both within the EU and in third countries with respect to labour rights, human rights and environmental protection. Efforts to improve the sustainable development of critical raw materials value chains will also help promote economic development in third countries, as well as sustainability governance, human rights, conflict resolution, and regional stability.

Member States will need to adopt and implement national measures to improve the collection of critical raw materials rich waste and ensure its recycling into secondary critical raw materials. Member States and private operators will have to investigate the potential for recovery of critical raw materials from extractive waste in current mining activities and from historical mining waste sites. Products containing permanent magnets will need to meet circularity requirements and provide information on recyclability and recycled content.

Source: European Commission, 16th March 2023. Press release

All stakeholders agreed that **the length and uncertainty of permit procedures are one of the main barriers hindering the development of domestic production of critical raw materials**. This Act aims to lessen administrative burdens and simplify the EU's permitting process. However, as per the stakeholders interviewed, the conditions for implementing these provisions are not currently met. Two main reasons contribute to this. Firstly, the procedures themselves are excessively lengthy. Before obtaining a permit, environmental impact assessments must be conducted, involving prolonged processes such as public consultations and responding to inquiries from the public. Secondly, there is a shortage of human resources within the national authorities responsible for issuing permits.

The interviewees highlighted Nordic countries among European Member States as more efficient in permitting procedures despite potentially being more stringent regarding green requirements. Mining has historically been well-acknowledged in countries such as Norway, Sweden, and Finland. In Southern countries, the primary issue is associated with social acceptance for two reasons: higher population density and potential competition between mining activities and the tourism industry.

Energy cost is another significant barrier to developing mineral extraction projects in Europe**.** Stakeholders interviewed indicated that the Commission's proposal to eliminate the lower tax on energy for mineral transformation within the "Energy Taxation Directive"[20] framework will exacerbate the situation. This proposition would diminish the competitiveness of European players, affecting not only the extraction industry but also the manufacturing sector that relies on these raw materials. There isn't a sufficient supply of renewable energy to replace traditional sources. Ultimately, this proposal will only make the business environment less attractive.

During interviews, stakeholders highlighted other environmental regulations that are perceived as problematic in terms of establishing mining capacity in Europe, such as the "Industrial Emissions Directive" (IED),[21] the Sustainable Finance Taxonomy,[22] "Corporate Sustainability Due Diligence Directive" (CSDDD),[23] and the "Ecodesign Directive (Directive 2009/125/EC)".[24]

Economic diplomacy visits are one of the tools to foster bilateral economic cooperation. **Trade agreements play a crucial role in diversifying supply sources, thereby mitigating supply risks**. According to a foresight study conducted by the JRC,[25] Australia and Canada are highlighted as key contenders for supplying the EU with a stable and low-risk flow of nearly all battery raw materials. Serbia is also recognized as a potential lithium source, while Norway is acknowledged as a supplier of flake graphite and potentially refined graphite.

In line with the OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas (2010)[26], several major markets, including the EU, Switzerland, China, and the USA have implemented or are in the process of implementing mineral supply chain due diligence through legislative measures and state-sponsored initiatives. For instance, Regulation (EU) 2017/821 sets forth due diligence requirements for EU importers of tin, tantalum, tungsten, their ores, and gold originating from conflict-affected and high-risk areas. These requirements assist companies in identifying and managing risks associated with the production and trade of mineral resources within global supply chains.

This signifies an expanding expectation for due diligence, encompassing a broader scope and deeper application. The European Commission aims to advance due diligence practices across value chains. The report on the implementation of the Strategic Action Plan on Batteries, issued on April 9, 2019, emphasizes the importance of due diligence and advocates for the ethical sourcing of battery raw materials (COM(2019) 176 final).

Efforts towards this direction are not exclusive to the EU; Member States are also actively engaged. Ministry officials regularly visit various countries to explore new trade markets and raw materials suppliers for companies based in EU Member States. National Trade Agencies, other service providers, and trade representatives in other countries assist EU companies in identifying new trading partners. More examples from specific Member States are listed as follows:

- In Lithuania:
    - Lithuanian companies are encouraged to use the resources of the Public Institution Innovation Agency to access international market research through platforms like Statista and millions of business contacts databases such as Orbis, aiding them in discovering potential business partners in other countries.

---

[20] https://energy.ec.europa.eu/topics/markets-and-consumers/energy-taxation_en
https://www.euractiv.com/section/economy-jobs/news/leak-the-belgian-presidencys-plan-to-unblock-the-eus-energy-taxation-directive/

[21] https://environment.ec.europa.eu/topics/industrial-emissions-and-safety/industrial-emissions-directive_en

[22] https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/eu-taxonomy-sustainable-activities_en
https://www.unpri.org/policy/eu-policy/eu-taxonomy

[23] https://commission.europa.eu/business-economy-euro/doing-business-eu/corporate-sustainability-due-diligence_en

[24] https://www.eceee.org/ecodesign/process/

[25] JRC (2023). Supply chain analysis and material demand forecast in strategic technologies and sectors in the EU – A foresight study. doi:10.2760/334074

[26] https://www.oecd.org/corporate/mne/mining.htm

For instance, the Orbis database gathers information about businesses involved in the supply of raw materials or components, searchable not only by country but also by region. The Orbis database is estimated to contain approximately 14,000 suppliers of wood and wood products, fertilizers, metals, and other raw materials based in Europe and the Middle East.

- In Poland:
  - The Ministry of Economic Development and Technology, in bilateral contacts with representatives of administrations of third countries, checks/analyses the possibilities of delivery and price conditions of raw materials and other products (e.g. artificial fertilisers) important for the Polish economy.
  - The State Raw Materials Policy aims to secure access to raw materials for the Polish economy through cooperation agreements concluded between the geological services of Poland and other countries to diversify the supply of raw materials. From the Polish point of view, the vast majority of strategic and critical raw materials are imported, so it is important to create a proper framework and partnerships with other countries. The geological information obtained in this way regarding mineral deposits is the beginning of the entire investment process related to the use of natural resources. Then, based on this information, specific mining investments are undertaken. These measures aim to reduce the risk of starting an investment in a given country. So far, Poland has concluded agreements for geological services with the Democratic Republic of Congo, Mongolia, Uzbekistan, Ukraine, Slovakia and the Dominican Republic.
  - Due to the situation in Ukraine, the Polish Development Fund, the Ministry of Foreign Affairs, and the Ministry of Economic Development and Technology launched a special hotline for Polish companies operating in Eastern markets. Entrepreneurs will receive information on sanction regulations and assistance for companies affected by the current situation, including searching for new sales markets and access to raw materials and components.
  - The Polish Investment and Trade Agency (PAIH), through Foreign Trade Offices, supports Polish companies in redirecting trade relations to alternative markets. As part of the PAIH Export Center, PAIH supports the search for outlets (export), alternative markets, e.g., other than Russia and Belarus, searching for markets for raw materials or components sourced so far from these directions (supply chains broken as a result of Russia's invasion of Ukraine and the accompanying sanctions and counter-sanctions), other raw materials and components used in the production process in Poland.
  - The Polish Agency for Enterprise Development, as part of the Enterprise Europe Network project, promotes a unique cooperation platform for supply chains among Polish entrepreneurs: The Supply Chain Resilience Platform, developed in cooperation with the European Cluster Cooperation Platform (and the European Commission. Its purpose is to mitigate the effects of trade contacts lost due to the war by establishing new business partnerships to maintain the supply of specific goods by acquiring them from other sources. The platform connects companies looking for specific goods with those that can offer them. It is designed for both businesses and humanitarian organisations.
- In Germany, at the beginning of January 2023, the German Federal Ministry for Economic Affairs and Climate Action (BMWK) published its Pathways to a sustainable and resilient supply of raw materials. The raw materials policy aims to provide companies with better support in diversifying their raw material supplies. BMWK is now implementing the foreseen measures, including a research programme for developing

sustainable processes and technologies and supplementing raw materials. This strategy also includes the establishment of a raw materials fund, which provides grants, equity, loans and guarantees to finance projects for raw material extraction, processing and recycling in the EU and outside.

These policy measures are not explicitly targeted at SMEs. Nevertheless, stakeholders have highlighted that SMEs could derive significant benefits from policies focused on diversifying and stabilizing access to raw materials. **SMEs** are particularly vulnerable to disruptions in the supply of strategic raw materials and would, therefore, **benefit relatively more from these policies compared to larger companies**.

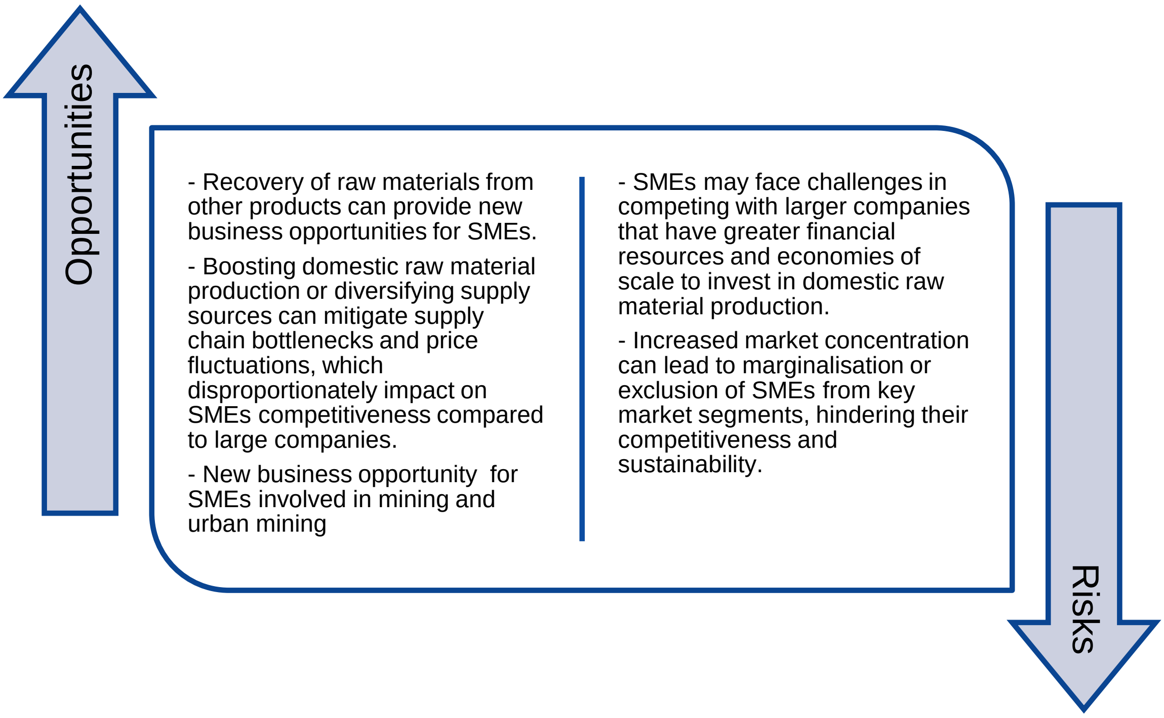
- **Contingency measures**: SMEs active in sectors dependent on strategic raw materials are less likely to already have in place contingency measures compared to large firms. They benefit from the monitoring mechanisms and the ability to jointly purchase stocks of strategic raw materials. This would directly strengthen their resilience against supply shocks, helping them to avoid the heavy costs associated with crisis mitigation.
- **Governance**: The establishment of the European Critical Raw Materials Board within the Critical Raw Materials Act (CRMA) includes provisions for regular meetings with stakeholder groups, some of which explicitly represent SMEs. This ensures that the interests and perspectives of SMEs are considered and voiced in strategic discussions.
- **Monitoring and information**: Enhanced monitoring and access to information about the supply chains of critical and strategic raw materials would particularly aid SMEs, which typically have less insight into supply chain risks compared to larger firms.
- **De-risk exploration activities**: Policies that streamline and simplify the permitting processes can significantly benefit SMEs that operate in the early stages of the value chain. These changes can decrease the risks associated with exploration, thus increasing their access to finance.
- **Recycling and circular economy**: SMEs can explore opportunities to recycle and recover raw materials from end-of-life products. This includes businesses focused on electronic waste recycling, scrap metal processing and other circular economy initiatives. In addition, there is a huge opportunity for SMEs in the collection phase, which is one of the bottlenecks of the recycling process and is more suitable to the characteristics of SMEs than large companies.
- **Innovation and technology**: SMEs can develop innovative technologies and solutions to improve efficiency, reduce waste, and enhance sustainability in raw materials extraction and processing.

Increasing EU strategic autonomy also presents several risks and challenges for SMEs:

- **Market consolidation at the expense of SMEs**: SMEs may face financial strain when attempting to increase production or diversify supply sources due to the significant investment required. Limited access to capital and financing options may hinder their ability to compete with larger enterprises. This risk is closely linked with the risk of further market consolidation, which can limit the presence of SMEs in the market and diminish their bargaining power compared to larger firms in negotiating prices, contracts, and terms with suppliers or customers. In a consolidated market dominated by a few significant players, SMEs may face challenges in competing effectively and negotiating favourable terms, potentially leading to marginalisation or exclusion from crucial market segments.
- **Regulatory burden**: SMEs operating in mining industrial minerals are more exposed to the negative effects and the loss of competitiveness from the complex European regulatory framework.

- **Social impact:** SMEs operating in local communities may face social tensions and conflicts over land rights and resource access. Limited resources and influence may hinder their ability to address social concerns and engage with stakeholders effectively.

Figure 4. Opportunities and risks for SMEs from higher strategic autonomy in raw materials



Source: Authors

1.3 Recommendations for future policy action

The EU confronts a pressing challenge in reducing its dependency on China for many critical raw materials (CRMs). While China has expanded beyond mere manufacturing to lead in scientific research output for green energy, **the EU's efforts to achieve autonomy in this domain through reshoring are hindered by high costs and slow progress**. The Critical Raw Materials Act, aimed at boosting domestic mining, refining, and recycling, still falls short in addressing the deeper issue of global CRM supply chain bottlenecks for intermediate goods.

To mitigate these challenges, Le Mouel and Poitiers from the Bruegel think tank[27] have proposed creating an **international strategy for CRMs**, leveraging instruments such as **investment and export credits** to diversify global supply chains. Another analyst from Bruegel, Garcia-Herrero[28], has proposed establishing a **Green Tech Partnership**, wherein a group of countries would collaborate in extraction, refining, manufacturing, and innovation activities through coordinated specialisation. This partnership would harness countries' capacities and comparative advantages across various aspects of the supply chain. To align

[27] Le Mouel M., Poitiers N. (2023), Wgy Europe's critical raw materials strategy has to be international. Bruegel Analysis. https://www.bruegel.org/sites/default/files/2023-06/why-europe%E2%80%99s-critical-raw-materials-strategy-has-to-be-international-%288941%29_1.pdf

[28] García-Herrero, A., H. Grabbe and A. Kaellenius (2023) 'De-risking and decarbonising: a green tech partnership to reduce reliance on China', Policy Brief 19/2023, Bruegel. https://www.bruegel.org/policy-brief/de-risking-and-decarbonising-green-tech-partnership-reduce-reliance-china

incentives for countries to join the partnership, strategies include ensuring access to green energy goods while reducing dependence on China-centric supply chains, mitigating the risk of path dependence on specific technologies, and providing access to technology transfer and raw materials for countries with significant economies of scale to manufacture. Specific instruments for the Green Tech Partnership could include **trade and investment agreements, technology transfer, financing, and carbon pricing**.

In addition to these international initiatives, **Member States also have room for more targeted policies**. Actions undertaken in Lithuania and Poland to assist companies in discovering new business partners or identifying areas in non-EU countries for investment to secure a stable supply of raw materials can serve as an interesting example to other Member States. Germany stands out as the sole major EU country with a comprehensive long-term plan to enhance access to raw materials, setting a model for others to emulate. Other actions can include:

- Member States should establish or strengthen mechanisms to distribute information about critical raw materials. This includes clarifying the opportunities available through national policies, highlighting the risks associated with the supply of certain critical raw materials, and outlining strategies for risk mitigation. For example, Germany utilizes a public agency to effectively communicate and manage these aspects.
- Procedures and permitting mechanisms need to be made fully transparent to reduce bureaucracy and enhance operational efficiency. This transparency will ensure that the processes are clear, understandable, and accessible, thereby improving the business environment for all stakeholders involved in critical raw materials.
- Each Member State should establish or improve national networks of raw materials centres. These centres would serve as key resources where SMEs can obtain crucial information regarding raw materials. These hubs would support SMEs in accessing up-to-date, relevant data and guidance tailored to their specific needs and challenges in the raw materials sector.

Recommendations specifically addressing critical raw materials relevant to particular technologies or ecosystems will be presented within the respective sections of the report.

2 OSA and SMEs in the textiles ecosystem

Highlights:

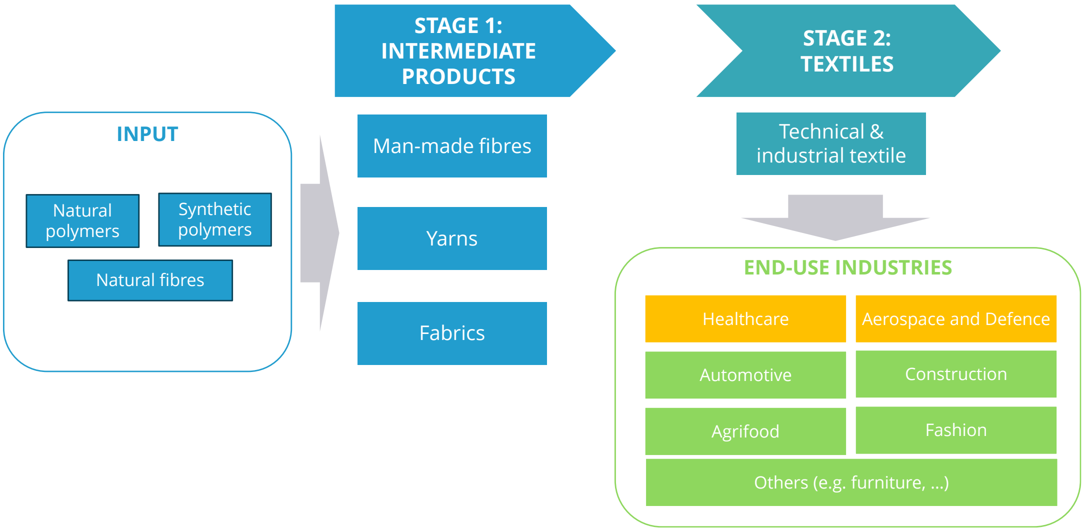
- Technical textiles are strategically important in healthcare as they are essential inputs for producing various key hygienic products and medical devices (e.g. face masks). They also play a strategic role in defence and aerospace, serving as crucial materials for manufacturing ballistic protection and protective clothing.
- SMEs constitute the backbone of the technical textile industry. Micro and small enterprises dominate the downstream stages of the value chain (more than 99% of companies), while upstream, there is a higher presence of medium and large companies due to their capital-intensive operations (15%).
- The industry faces significant competition from China, which has emerged as the global leader in manufactured fibres. Additionally, other Asian countries have established major innovation hubs, posing a threat to the leadership of EU producers in higher-value-added products.
- The EU industry involved in the production of man-made fibres and technical textiles has recently undergone consolidation, with SMEs merging or being acquired by larger corporations to boost international competitiveness and benefit from economies of scale.
- While dependency on inputs from extra-EU countries (raw materials, chemicals, man-made fibres) seems impossible to reduce in the short and medium term, the EU could leverage its competitive edge in R&D to consolidate its technological leadership and strengthen its productive capacity in critical technical textile finished products.
- A few Member States, during the COVID-19 pandemic, have directly supported companies to help them convert their production process to manufacture strategic non-woven articles. However, these investments were highly costly, and the price of the final products could not compete with those of the Chinese.
- Inadequate enforcement of market surveillance is the main threat to the sustainability pathway of the textile industry. Without a functioning market surveillance system, EU SMEs can’t compete with international competitors. They might be forced out of the market or compelled to relocate their production outside Europe.
- Policy action to increase benefits and opportunities for SMEs should adopt a holistic approach, including better protection against unfair competition from third countries; dedicated support for innovation; financial support to cope with the green transition; communication campaign about implemented measures among different levels of authorities; market intelligence to improve data on the actual production capacity and specialisation of EU SMEs within the value chain; support for skills development and expansion of the labour force in this sector.

2.1 Overview of the value chain, positioning of SMEs and strategic vulnerabilities

This section addresses the issue of OSA in the textile ecosystem, where technical textile is regarded as the most strategic and vulnerable product. **Technical textiles are defined as**

textiles, fibres, materials, and support materials that meet technical criteria rather than aesthetic ones. Their value chain encompasses a range of interconnected activities, including processing natural and synthetic fibres, yarns and fabrics. Specialised textiles serve as inputs to various industries such as automotive, healthcare, defence and aerospace, construction, agri-food, and other sectors (e.g., furniture, clothing, etc).

Figure 5. Value chain of the technical textile industry



Source: Authors

The textile ecosystem is one of the most globalised value chains that exist today.[29] Since the termination of the “Multi-Fibre Arrangement and Agreement on Textiles and Clothing” (MFA/ATC) and the elimination of import quotas on textile and clothing products in 2005,[30] significant transformations have occurred within the global textile industry and its value chain structure. The following major trends have emerged:

- **Offshoring and relocating lower-value manufacturing activities** outside the EU have played a crucial role in enhancing competitiveness for numerous European brands operating in both the textile and clothing sectors. Following the end of the MFA/ATC, Asia (initially China, followed by ASEAN[31] and SAARC[32] countries) became the primary destination for outsourcing. More recently, nearshoring to the Mediterranean region (including Turkey, Tunisia, Morocco, and Egypt) has gained prominence due to its ability to facilitate faster market entry into the EU and streamline supply chain management.
- Upstream in the value chain, **China has emerged as the global leader in man-made fibres** (MMF).[33] Certain fibres, notably polyester and key chemicals, have been targeted by the country’s Five-Year Plans over the years. The industry has attracted substantial public subsidies to bolster an extensive production capacity, resulting in a distortion of competitive dynamics. Today, overcapacity in man-made fibres is structural and further growing globally, as confirmed by numerous interviewed stakeholders. As a consequence, many players worldwide, including in Europe, have

[29] European Commission (2021). Data on the EU Textile Ecosystem and its Competitiveness

[30] WTO. Agreement on Textiles and Clothing. Available at: https://www.wto.org/english/docs_e/legal_e/16-tex_e.htm

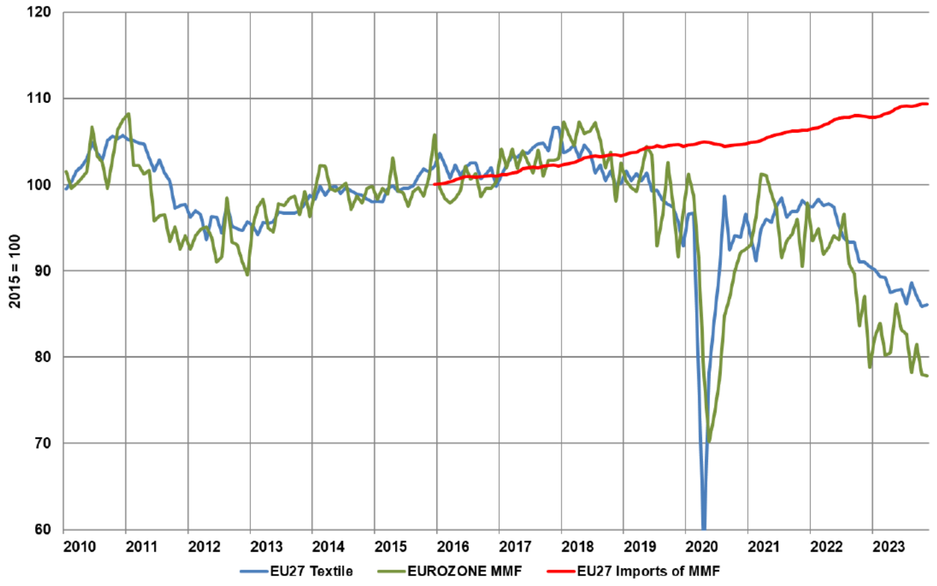
[31] ASEAN (Association of Southeast Asian Nations) includes Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam

[32] SAARC (South Asian Association for Regional Cooperation) Member States are Bangladesh, India, Maldives, Nepal, Pakistan, and Sri Lanka

[33] In the textile ecosystem, the importance of MMF has increased exponentially since the mid-nineties. Today, they supply almost 80% of the entire fibre demand, while natural fibres, such as cotton and wool, have remained quite stable over the last 50 years.

been compelled out of the market. For certain MMF, there may be just one producer left in the EU, such as acrylic fibres in Portugal, or even no producer at all, like elastene. Today, China accounts for 70% of the global production of MMF. Europe ranks third after India.[34]

Figure 6. Production volume of textile, MMF, EU27 imports of MMF, 2010-2023 (percentage change)



Source: CIRFS

During the COVID-19 pandemic, the trade of technical textiles experienced comparatively less decline than other segments due in part to sustained production and export of non-wovens. These materials **proved strategically significant throughout the crisis**, serving as essential inputs for producing several critical items, including face masks. Within the EU, non-woven production is primarily concentrated in Italy, Germany, and, to a lesser extent, France. However, these countries experienced a decline in their exports in 2020, while imports from China surged. In 2019, **Since 2010, China has held the title of the world's largest non-woven producer, driving exports of technical and industrial textiles**.

Downstream in the value chain, **EU producers have maintained their leadership position in higher-value-added finished products**. Nevertheless, developing economies have aimed to bolster their international competitiveness by diversifying away from traditional specialisations and venturing into higher value-added sectors. Particularly **in technical and industrial textiles, innovation hubs have emerged in Asia** (such as China, Taiwan, Indonesia, and India), with some companies transitioning into the sustainable textile market and pioneering the development and marketing of bio-based materials.

Currently, **dependencies on raw materials and chemicals, particularly dyestuffs and resins, pose significant concerns for competitiveness** within the entire textile ecosystem in Europe. **The energy crisis that began in 2022 has further exacerbated these concerns**. The sharp increase in energy and raw material prices has led to higher production costs, particularly affecting energy-intensive sectors such as MMF and non-woven products. Despite some reduction since 2022, the cost of energy and raw materials remains considerably higher in Europe compared to the US and Asia.[35] On one hand, the industry has made substantial

[34] According to CIRFS (European Man-made Fibres Association) data, Europe has very small, only 3.2 million tonnes compared to the 81.5 million tonnes manufactured worldwide, with a strong specialization in Polyolefin, PP or PE that serve geotextile, agro-textile and in some non-woven applications.

[35] Textile Technology (2024). European MMF industry challenges 2024. Article available at https://www.textiletechnology.net/fibers/commentary/cirfs-european-mmf-industry-challenges-2024-35211

investments in chemical recycling, a process that demands significantly more energy than conventional production methods. On the other hand, MMF continues to face strong price pressures from China. These combined factors have resulted in production cutbacks, insolvencies, and competitiveness issues throughout the entire value chain.

Despite these challenges, **technical and industrial textile manufacturing capacities have demonstrated greater resilience compared to other segments within the textile industry**. The stakeholders interviewed reported that it was the fastest-growing sector within the textile ecosystem since the beginning of the energy crisis. Within the EU, the technical textiles industry represents approximately 30%[36] of the total turnover in textiles.[37] Its dynamism and significant economic impact characterise it. In contrast to the labour-intensive nature of the clothing and fashion subsectors, the technical textile industry represents a high-value-added sector characterised by capital-intensive activities. In 2018, technical textiles achieved a production value of EUR 21.8 billion and a turnover of EUR 23.3 billion, employing 151,000 workers in 14,700 companies. While overshadowed by the Chinese result (EUR 85.6 billion), the EU's production output surpasses the production figures of other principal competitors, notably the USA, standing at EUR 8 billion. Extra-EU exports comprise only 26% of turnover (2018), a figure that has remained relatively stable over time. Although these exports have experienced growth, they do not represent the primary driver of the EU's expansion in this business sector. Despite this, value added in the technical textiles segment experienced rapid growth, outpacing turnover. Notably, investment is substantial, with fixed investment in the EU27 amounting to EUR 1 billion in 2018, representing 5% of the production value. Apparent labour productivity within technical and industrial textiles is among the highest in the ecosystem, surpassing the average productivity in the textile ecosystem.[38]

The EU27 emerges as a critical source of innovations for the technical textile industry, with the highest number of patents in the world. The European Commission, in its study "Assessing Open Strategic Autonomy"[39], has identified the textile ecosystems as one with high levels of innovation sovereignty despite a heavy reliance on imports, especially from China, Turkey, and Vietnam. Beyond the quantitative evidence, European firms can count on a network of research institutes that collaborate with firms in the development of new fibres and materials.[40]

[36] European Commission (2020). Advanced Technologies for Industry – Sectoral Watch European strengths in technical textiles

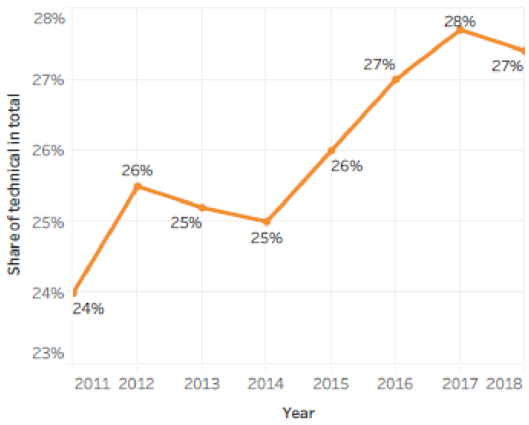
[37] Despite global competition, the EU27 remains a major player in the textile and fashion industry, with a production value of 197.6 billion EUR in 2018 and significant exports both within and outside the EU.

[38] European Commission (2021). Data on the EU Textile Ecosystem and its Competitiveness.

[39] JRC (2024). Assessing Open Strategic Autonomy: A two-dimensional index to quantify EU-27 autonomy in industrial ecosystems and strategic technologies https://op.europa.eu/en/publication-detail/-/publication/524071d9-ab81-11ee-b164-01aa75ed71a1/language-en

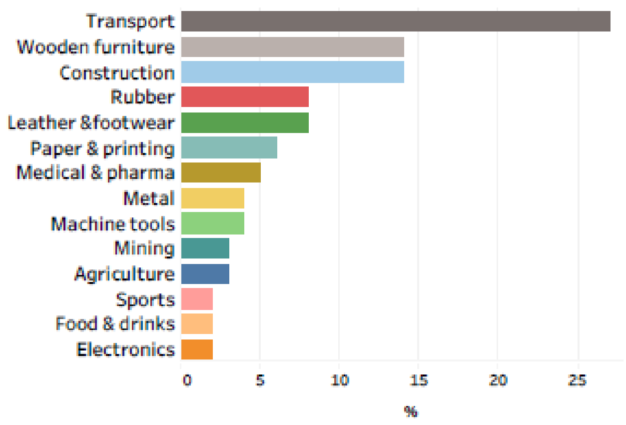
[40] European Commission (2021). Data on the EU Textile Ecosystem and its Competitiveness.

Figure 7. Share of technical textiles in total production



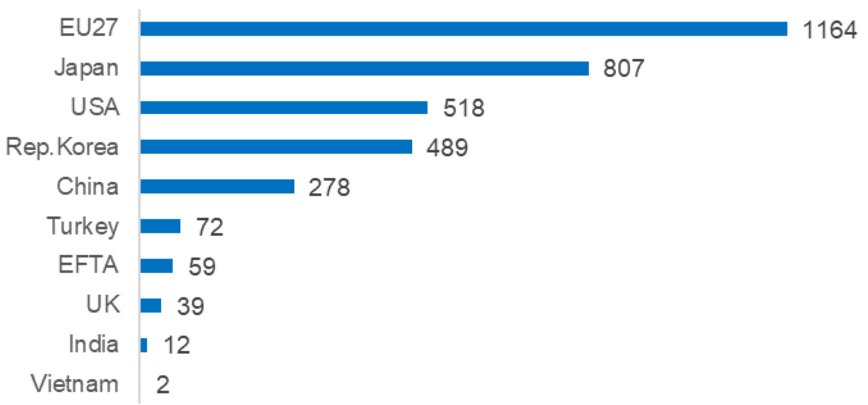
Source: Euratex

Figure 8. Technical textile usage in different end markets in Europe



Source: Innovative cross-border approaches for Textile and Clothing Cluster co-development in Mediterranean basin, 2014

Figure 9. Total number of patents filled in in the technical and industrial textile industry by geographic areas (total number 2015 – 2019)



Note: the technical and industrial textile industry corresponds to IPC codes D04, D05, D07.
Source: Authors elaboration on data from the European Commission (2021). Data on the EU Textile Ecosystem and its Competitiveness

SMEs dominate the technical textile industry, including a large share of microenterprises. Approximately 17,600 SMEs operate along the technical textile value chain, employing around 137,500 individuals.[41] This capillary system of SMEs includes both top brands and artisanal SMEs producing specialised products for niche markets. Additionally, in the sectors of protective garments and medical textiles, SMEs provide ancillary services such as tailoring, reprocessing, and repair services.

Italy and Germany hold the most prominent positions in the European technical textile industry across nearly all stages of the value chain, generating the highest values in terms of production and turnover. While micro and small enterprises dominate Italian production, German players are relatively larger in scale. In terms of the number of SMEs active in technical textiles by Member State, France has the largest number (mainly microenterprises,

[41] These estimates are derived by the authors through the analysis of Eurostat's "Structural Business Statistics" database. They specifically concentrate on technical and industrial textiles and their value chain, excluding home textiles.

accounting for 95%), followed by Italy, Poland, Spain, Portugal, and Germany. However, when considering the total number of persons employed by SMEs per country, Italy and Germany emerge as the European leaders, both employing more than twice the number of individuals employed by French SMEs. A similar ranking holds in terms of added value and turnover, where production is dominated by Italy and Germany, followed by France and Spain.

The industry is more concentrated in the upstream segments of the value chain. The production of **manufactured fibres**, which resemble the chemical and plastic industries, is dominated by medium and large companies due to their capital-intensive nature. Stakeholder interviews reveal that **the European industry has experienced a period of consolidation in the last few years**. Many SMEs have merged or been acquired by larger corporations to enhance international competitiveness, leveraging economies of scale and synergies. This trend primarily affects capital-intensive entities upstream in the value chain, such as man-made fibre producers, weavers, and spinners. SMEs involved in manufacturing finished technical textiles products are also impacted, albeit to a lesser extent.

Table 2. Share of micro, small, medium, and large enterprises by segment (2021)

Subsector	Man-made fibres	Yarns	Fabrics	Home textile; Technical & industrial textile; part of Fabrics
Micro entreprises (0-9 empl.)	58.2%	72.6%	83.9%	88.0%
Small entreprises (10-49 empl.)	18.7%	20.6%	12.2%	9.5%
Medium entreprises (50-249 empl.)	12.7%	5.9%	3.4%	2.2%
Large enterprises (more than 250 empl..)	1.0%	1.0%	0.4%	0.3%
Total	100%	100%	100%	100%

Note: Man-made fibres correspond to NACE code C131-Manufacture of man-made fibres; Yarns correspond to NACE code C131-Preparation and spinning of textile fibres; Fabrics correspond to NACE codes C132-Weaving of textiles, C133-Finishing of textiles; Home textile; Technical and industrial textile; part of Fabrics corresponds to NACE code C139-Manufacture of other textiles.
Source: Eurostat-sbs_sc_ovw, Enterprise statistics by size class and NACE Rev.2 activity (from 2021 onwards)

2.2 OSA goals and overview of relevant policy initiatives

The strategic importance of technical textiles lies particularly in their value for healthcare, defence and aerospace applications (see Table 3). The healthcare sector's strategic relevance became especially apparent during the pandemic, as technical textiles are essential inputs for producing various key personal protective equipment and medical devices crucial for managing sanitary emergencies. Regarding defence and aerospace applications, the European Commission's "Transition Pathway for the Textile Ecosystem" highlights that certain textile products are indispensable to support defence efforts and non-defence sectors. Specifically, the Commission recommends strengthening composite structures for ballistic protection and protective clothing, prioritising the production of textiles used in defence systems and weaponry. Equally critical are tents, shelters, parachutes, military uniform fabrics, leather boots, and protective gear.

Table 3. Technical textile products for medical and defence applications

Category	Examples
Clothing	Uniform, Workwear, Personal protective equipment, Protective garments
Automotive, tyre and Mechanical Rubber Goods	Passenger car tyres, off-road tyres, aircraft tyres, Conveyor belts, airsprings, Hoses, Chafer for tyres, rubber boats, mats/carpets, etc.

Ropes, Nets, Tows and Strappings	Ropes, Nets, etc.
Airbag applications	Vehicles, Helicopters, Cargo airplanes, etc.
Broad fabrics	Roofing, Tents, Sail and filtration cloth, Conveyor belts, Silos/containers, Tarpaulins, Geotextiles, etc.
Medical	Face masks, Medical gowns and draipers, Implantable medical fabrics, Hygiene products, Wound care, Trans-dermal drug delivery, etc.

Authors: CIRFS

According to the existing strategic and policy documents for the textile ecosystem, as well as interviews with stakeholders, the strategic approach to technical textiles production within the OSA framework should focus on safeguarding current EU production levels and boosting manufacturing activities across the value chain of technical textiles, especially for medical and defence applications. Europe's leadership in innovation and sustainability in this specific sector can drive competitiveness. On the other hand, the rising production costs for European companies, stemming from increased energy expenses and sustainability standards, highlight the necessity for strengthening and more rigorously enforcing market surveillance measures.

During the pandemic, **some Member States, such as Germany and Italy, directly supported companies to help them convert their production** process to manufacture strategic non-woven articles. Conversely, according to interviewed stakeholders, public funds covered only a small portion of the conversion process. Most investments were natural market responses to business opportunities. The role of SMEs was crucial, especially in the initial phase, as they have more flexibility in shifting production and proposing innovative solutions. The bottom-up push from SMEs towards the involvement of large brands proved effective, creating a positive domino effect. The number of EU companies manufacturing face masks at least doubled.[42] However, Europe did not seize this opportunity entirely. Limited policy actions and institutional support in several countries were seen as a barrier and resulted in a “lost opportunity”.

In contrast, significant public support was given in China to expand its production capacity of face masks. As a result, during the pandemic, EU consumption needs were largely covered by imports, with Asia covering all stages of the supply chain and Europe only taking care of the sterilisation phase. China was and still is the largest provider of face masks for the EU27. In 2019, the EU27 imported made-up articles of textile materials for a value of EUR 1.03 billion. By 2020, this amount had increased by 19 times, with imports reaching a value of EUR 19.9 billion. After the Covid-19 pandemic, European-manufactured products could not compete with lower-priced Chinese imports as demand decreased. Consequently, the investments made in 2020, encompassing machinery, know-how, and certifications, became vastly underutilised. While a few established companies successfully re-adapted their production lines, the majority of new entrants, who lacked both experience and a market for their products (except for air filtration applications), found their operations economically unsustainable and were forced to shut down.

Box 5: Example of subsidies to face mask production during COVID-19 in Germany and Italy

On June 3rd, 2020, the **German federal government** announced the agreement on a **stimulus package of EUR 130 billion**. The package set out to strengthen the healthcare system and improve pandemic preparedness. One of the goals of the stimulus package was

[42] Interviewed stakeholders report in March 2020, in Europe, there were 5-6 meltblown production plants. Between 2020 and 2021, 23 more machines were added, representing a five to six-fold increase.

to increase the capacities and independence in the production of Personal Protective Equipment (PPE). For this purpose, financial support of EUR 1 billion was granted to build up strategic reserves of PPE both at federal and state levels and in medical facilities.[43]

In **Italy**, the *Cura Italia* plan[44] initially allocated **EUR 50 million** to assist companies in transitioning to mask production;[45] however, these funds were quickly depleted. The Italian government then decided to rely on large industries. Former FCA Italy (now Stellantis) was funded to produce masks, which were distributed mainly to schools and other public institutions such as police and public companies.[46]

Source: Authors

Safeguarding local production and developing contingency plans for textile products with defence and security dimensions offer an opportunity to address vulnerabilities and dependencies in strategic areas within the textile ecosystem. Fabrics and technical textiles designed for defence applications predominantly serve business-to-government (B2G) markets, where pricing is a pivotal determinant of competitiveness. European manufacturers encounter challenges in competing with imports from countries like China and Bangladesh, where labour costs are significantly lower. Countries such as the USA and Canada stipulate in their procurements that procured products must originate domestically to protect local production (see more information in the following Box 6).

Box 6: Defence Procurement Strategy in the USA

Two US Laws require that certain products purchased by the Department of Defence (DOD) and some Department of Homeland Security (DHS) agencies be manufactured and wholly produced within the United States.

The Berry Amendment requires certain items purchased by DOD to be 100% domestic in origin. The items covered by the law have varied over the years; currently, **the Berry Amendment** applies to DOD purchases of textiles, clothing, footwear, food, hand or measuring tools, stainless steel flatware, and dinnerware. DOD purchases of these items must be entirely grown, reprocessed, reused, or produced in the United States.

The Kissell Exceptions include various exceptions to the Berry Amendment. DOD, for example, can buy from non-US sources when:

- products are unavailable from American manufacturers at satisfactory quality and sufficient quantity at US market prices;
- items are used in support of combat operations or contingency operations;
- products are intended for resale at retail stores such as military commissaries or post exchanges;
- purchases are part of a contract whose value is at or below the Simplified Acquisition Threshold (USD 250,000).

[43] European Observatory on Health Systems and Policies (November 2020). COVID-19 Health System Response Monitor (HSRM). Country: Germany. Policy response: "2.1. Physical infrastructure. Physical infrastructure». Available at: https://eurohealthobservatory.who.int/monitors/hsrm/hsrm-countries/hsrm/germany/ensuring-sufficient-physical-infrastructure-and-workforce-capacity/physical-infrastructure/

[44] Cura Italia website. Available at https://www.curaitalia.it/progetto

[45] Sole 24 Ore (25th April 2020). Invitalia, a 50 aziende incentivi alla riconversione per produrre mascherine. Available at: https://www.ilsole24ore.com/art/invitalia-50-aziende-incentivi-riconversione-produrre-mascherine-ADgh0ZM

[46] La Stampa (4th August 2020). Coronavirus, Fca produrrà 27 milioni di mascherine al giorno a Torino e Avellino. Available at: https://www.lastampa.it/torino/2020/08/04/news/coronavirus-fca-produrra-27-milioni-di-mascherine-al-giorno-a-torino-e-avellino-1.39158378/

In FY2021, FPDS-NG[47] data indicate that food and apparel purchased by DOD comprised approximately 92% of the department's total Berry-specific contract obligations. DOD's procurement of textile and apparel articles, including clothing and footwear, amounted to USD 2.3 billion, representing 43% of the Department's total Berry-applicable purchases. Of these purchases, DOD expenditures specific to clothing amounted to USD 1.7 billion. Purchases subject to the Berry Amendment represented 5% of the USD49 billion of textile and apparel shipments from US mills in 2021.

Source: Congressional Research Service. Buying American: The Berry and Kissell Amendments (Updated January 20, 2023)

While Europe lacks a specific law akin to the Berry Amendments, which mandate local content requirements for military textiles in procurement practices, an interviewed stakeholder suggested that **some levels of protection at the MS level are effectively applied during the procurement stages**. For example, in Italy, modifications have been made to older tender specifications to accommodate the local availability of materials with similar performance. Polyester yarns, which are no longer produced within Europe, have been substituted with polyamide yarns. This adaptation is supported by a fully verticalized supply chain in Italy, ensuring local sourcing. This approach mirrors lessons learned from Russia's experience post-2014, when, following the annexation of Crimea and subsequent sanctions, it was compelled to revitalize its previously neglected textile supply chain to reduce dependency on foreign military equipment procurement Box 6).

Box 7: Russia Establishes Technical Textile Cluster in Response to War Sanctions

Before 2014, Russia predominantly relied on imports to meet its industry demands for technical and advanced textiles. However, the imposition of economic sanctions by the European Union and the U.S., coupled with the withdrawal of some leading foreign producers from the Russian market, compelled the Russian government to consider establishing domestic production capabilities for these materials. Additionally, the cessation of exports to Russia by many international producers further emphasized the need for local development.

In response, the Russian government allocated up to **USD 300 million for the years 2016 and 2017 to develop the technical textiles industry**. The majority of these funds were designated to subsidize interest on loans provided by Russian banks to manufacturers. These loans were explicitly targeted at technically re-equipping the industry and enhancing research and development activities in advanced textiles.[48]

Further investment came in 2018 when the government committed another **USD 300 million to the design and production of new speciality fabrics and technical textiles** tailored to the needs of the Russian military for the 2017–2018 period. This funding was part of a record state defence order approved in 2017, which included extensive re-armament programs for the military. The order specifically allocated funds to increase the supply of speciality fabrics and technical textiles to support Russian military forces in the coming years.[49]

Source: Authors

[47] Federal Procurement Data System - Next Generation

[48] Advanced Textiles Association (October 2016). Advanced textiles in Russia. Article available at: https://www.textiles.org/2016/10/01/advanced-textiles-in-russia/

[49] Advanced Textiles Association (February 2018). Investments in technical fabrics for the Russian military. Article available at: https://specialtyfabricsreview.com/2018/02/01/military-markets/

In 2023, the European Commission[50] emphasised the need to develop plans to increase the readiness to shift production and prioritise deliveries for defence purposes to sustain the Armed Forces, defence companies and other relevant sectors in case of crises or war. This requires setting up **contingency plans to handle disruptions in supplies of inputs** as well as **plans to handle situations where the workforce is mobilised for war efforts**. The Commission pinpointed Italy and Germany as pivotal players in implementing this strategy. As a significant EU producer of fabrics and apparel, Italy can establish the necessary facilities to diversify the existing production. Germany, which is the major producer of technical textiles, also has the potential to expand its production capacity to support defence initiatives effectively.

Some measures are already in place to serve this purpose. The European Defence Fund (EDF),[51] with a budget of nearly EUR 8 billion for 2021-2027, provides funding opportunities for the textiles ecosystem. Already under the *Preparatory Action on Defence Research*, a precursor programme of the EDF granted an award to VESTLIFE, a project focused on the development of lightweight and bulletproof garments.[52] The *Pact for Skills for the Textiles ecosystem*, a measure aimed at mobilising relevant stakeholders to address challenges related to upskilling and reskilling the workforce, could be used to strengthen the resilience of the ecosystem during a crisis.

Investment in new materials and product innovation are the main ways to sustain Europe's technological leadership in technical textiles. This requires public and private investment in R&D, knowledge transfer from academia to businesses, improving intellectual property management, and innovation-friendly regulation. Several funding opportunities are available for the textiles ecosystem, such as Horizon Europe, Digital Europe, LIFE, ESF+, InvestEU, Innovation Fund, the Single Market Programme, Cohesion Policy Fund and Recovery and Resilience Facility.

However, stakeholders interviewed underscored the difficulties textile SMEs encounter when competing for available R&D funds, particularly against industries like pharmaceuticals or automotive, where larger, more established players dominate. This is also reflected in the distribution of projects funded by the European Regional Development Fund (ERDF).[53] According to an ongoing ex-post evaluation conducted by CSIL, no specific program measures were expressly designed to cater to the textile ecosystem during the operational period 2014-2020. Among all ERDF-funded operations that aimed to enhance SME competitiveness, less than 1% had companies in the textile sector among their beneficiaries. One of the few examples of funding programmes specifically targeting the textile sector is a dedicated Horizon Europe partnership program for textiles, called Textiles for the Future,[54] aimed at fostering research and innovation within the textile sector, with approximately EUR 60 million allocated within Horizon Europe for this purpose, with additional co-financing from participating companies. The original proposal presented by Euratex, Sustainable Textiles European Partnership,[55] was more ambitious, claiming a budget of EUR 1 billion.

Sustainability and circular practices are at the core of the EU industrial and innovation strategy for the textiles ecosystem.[56] This approach positions European technical textiles as

[50] European Commission (2023). Transition pathway for the textile ecosystem

[51] https://defence-industry-space.ec.europa.eu/eu-defence-industry/european-defence-fund-edf_en

[52] https://defence-industry-space.ec.europa.eu/eu-defence-industry/preparatory-action-defence-research-padr_en

[53] https://ec.europa.eu/regional_policy/funding/erdf_en

[54] European Commission (2023). Co-funded and co-programmed European Partnerships under the second Horizon Europe Strategic Plan: Draft concept papers for proposed candidate partnerships, p. 55. Available at: https://research-and-innovation.ec.europa.eu/document/download/04162ca0-b5db-4773-bd47-d75ff1af1723_en?filename=ec_rtd_candidate-list-european-partnerships.pdf

[55] Euratex (2023). STEP2030. Manifesto draft. Available at: https://euratex.eu/wp-content/uploads/STEP2030-Manifesto_final_evaluated-10.07.23.pdf

[56] European Commission (2022). EU Strategy for Sustainable and Circular Textiles.

frontrunners in **satisfying the demand for sustainable products in the EU and worldwide**. However, all interviewed stakeholders concurred that price remains the primary factor influencing purchasing decisions in Europe and internationally. Consequently, European regulations that mandate higher technical and sustainability specifications standards present competitive challenges for European firms.

Policy measures such as Green Public Procurement[57] rules can support European companies by leveraging their strengths in sustainability. An illustrative example of such a policy is Italy's Minimum Environmental Criteria,[58] implemented during COVID-19. This decree prioritizes reusable textiles for medical devices in all public procurement tenders in Italy. Stakeholders have highlighted this measure as significantly beneficial to local SMEs.

Box 8: Reusable Materials, a Sustainable and Alternative Model

Considering products such as face masks, medical gowns, and drapes, Europe cannot compete on quantity alone. Stakeholders suggest a paradigm shift is necessary, explicitly **favouring reusable over disposable materials**. Although cheaper initially, disposable textile products generate significant waste and require special treatment. They are non-recyclable and necessitate considerable energy for disposal. For such medical devices, there is an opportunity to develop washable and long-lasting products in collaboration with specialized laundry facilities. These durable, high-quality, and high-margin products align more closely with the strengths of European manufacturing. To remain competitive and ensure a 70-90 wash lifespan, these products must be highly technical, featuring an initially higher unit cost that becomes more cost-effective over time.

Source: Authors

Nevertheless, establishing a **level playing field is essential to fully leveraging competitive advantages in sustainability practices**. To ensure fair competition with third countries, differences in social and environmental standards that threaten the competitiveness of EU-made products shall be addressed. In addition, SMEs are more vulnerable to predatory trade practices than larger players. Given their sheer numbers and constrained financial resources, coordinating and supporting costly legal actions against unfair trade practices poses significant challenges for them. Market surveillance and controls at the EU's external borders play a crucial role in ensuring fair competition in the Single Market and safeguarding the competitive edges of European SMEs. The *Market Surveillance Regulation*[59] lays down a framework for enforcing product compliance rules within the internal market, by market surveillance authorities, and at EU external borders by the designated authorities.

With regard to market surveillance, the European Chemicals Agency announced that inspectors in Member States check textile products for compliance with restrictions for hazardous substances.[60] Free Trade Agreements (FTAs)[61] are considered an effective tool to support operators in internationalising their operations and promoting environmental and social legislation with trading partners. In particular, the Trade and Sustainable Development Chapter can help enforce environmental and social standards.

[57] https://green-business.ec.europa.eu/green-public-procurement_en

[58] Minister of ecological Transition Decree (30th June 2021): https://www.mase.gov.it/comunicati/ambiente-ministro-costa-firma-decreto-sui-cam-tessili-materassi-e-dispositivi-medici

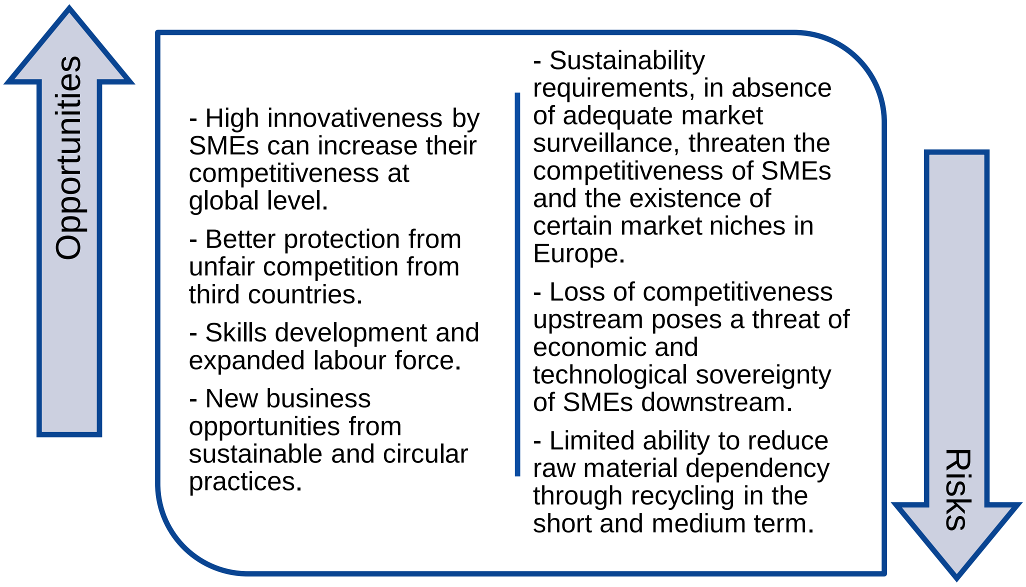
[59] Regulation (EU) 2019/1020 of the European Parliament and of the Council of 20 June 2019 on market surveillance and compliance of products and amending Directive 2004/42/EC and Regulations (EC) No 765/2008 and (EU) No 305/2011 (Text with EEA relevance.). Available at: https://eur-lex.europa.eu/eli/reg/2019/1020/oj

[60] On July 1, 2020, the European Chemicals Agency (ECHA) announced that its inspectors would check products for compliance with restrictions for selected hazardous substances under REACH. Article available at: https://www.sgs.com/en/news/2020/07/safeguards-11020-eu-market-surveillance-on-textile-and-footwear-products

[61] https://trade.ec.europa.eu/access-to-markets/en/content/free-trade-agreements

Finally, **the shortage of skilled workforce is a significant source of vulnerability for the technical textile industry** and the entire ecosystem. An ageing workforce and difficulty in attracting new skilled employees (particularly young ones) have been identified both in the literature and by stakeholders as major barriers hindering the development of internal production capabilities. The European Commission has launched the EU Pact for Skills initiative,[62] a central element of the European Skills Agenda. Under this EU initiative, the European Commission and the business associations Euratex, Cec and Cotance supported the establishment of a large-scale skills partnership for the textiles ecosystem. Launched in December 2021, the EU Pact for Skills for the Textiles ecosystem aims to promote the up/re-skilling and transferring of green and digital skills. It encourages commitments through specific actions and creating multi-stakeholder local skills partnerships.

Figure 10. Opportunities and risks for SMEs from higher strategic autonomy in technical textile



Source: Authors

As previously mentioned, SMEs constitute the backbone of the technical textile industry. Any policy or strategy related to OSA would directly affect SMEs. Increasing OSA in the technical textile value chain would yield **several benefits** for SMEs, including fostering innovation, providing better protection against unfair competition from third countries, supporting skills development, and expanding the labour force. Introducing sustainable and circular practices, such as favouring reusable over disposable products, will create significant opportunities for SMEs in reprocessing, repairing, and recycling.

At the same time, increasing EU strategic autonomy presents **various risks** and challenges for SMEs in the textile industry, which are summarised hereby:

- **Market surveillance activities are not adequately implemented, posing a severe threat to the competitiveness of European technical textiles SMEs**. This issue was raised by most interviewed stakeholders, who identified the limitations in terms of market surveillance as the main threat to the sustainability pathway of the textile industry. The European Commission funded the implementation of a REACH for Textile project,[63] which aimed to verify compliance with imported textile products in

[62] https://pact-for-skills.ec.europa.eu/about/industrial-ecosystems-and-partnerships_en

[63] https://euratex.eu/reach4textiles/#:~:text=The%20REACH4texiles%20project%20aims%20at,textiles%20and%20applying%20the%20EU

collaboration with market surveillance authorities. The results reveal minimal control level, confirming a significant gap in effective market surveillance.

- **Sustainability regulations are affecting the performance of technical textiles, potentially jeopardizing the viability of European production in specialized market niches often occupied by SMEs**. As part of the broader textile strategy to transition towards a more sustainable industry, there is significant pressure to reduce the use of certain chemicals. According to stakeholders, this reduction can hinder fabrics from achieving the necessary performance levels. From an efficiency and functionality standpoint, the industry requires some of these now-regulated chemicals to meet performance standards.[64] Consequently, if companies cannot use these essential chemicals, they might be forced out of the market or compelled to relocate their production outside Europe. This issue is particularly acute in niche markets like military garments and uniforms, where SMEs dominate.

- **Interdependencies across different segments of the ecosystem**. Stakeholders interviewed emphasised the need for a holistic approach to address dependencies in specialised applications within the technical textile industry. Capital-intensive companies involved in upstream activities like fibre production, weaving, and knitting incur significant fixed costs. To ensure profitability and sustainability, these companies must diversify into lower-value market segments alongside specialised technical textile products. Untangling these complex relationships presents a challenge that must be carefully considered in any OSA measure for the technical textile value chain.

- **Loss of knowledge**. An OSA strategy for technical textiles should consider the dynamics and specificities of different value chain segments. Specifically, if an OSA strategy fails to address the challenges encountered by companies operating in the upstream segments, dominated by larger-sized companies, it could lead to a loss of valuable knowledge and competitive edge. Recent bankruptcies among these upstream companies led to the loss of previous R&D investments and impacted downstream SME players. Collaboration across different stages of the supply chain is essential for fostering innovation. However, the loss of local upstream production may force EU SMEs to collaborate with foreign suppliers, potentially resulting in the erosion of technological sovereignty.

- **High energy prices**. Although energy prices in the EU have decreased since 2022, they remain higher than those in the USA and Asia, presenting a significant challenge to the competitiveness of energy-intensive sectors such as manufactured fibre production. The failure to address these energy costs not only jeopardizes the competitiveness of these sectors but also risks the potential loss of segments of the value chain within the technical textile industry. This underscores the importance of incorporating energy cost considerations into any OSA strategy to enhance the competitiveness of the technical textile industry.

- Most interviewed stakeholders concurred that **reducing dependency on raw materials for technical textiles through recycling has limited scope**. Specifically, recycling technical textiles, particularly those used in personal protective equipment for medical and military applications, poses several challenges. The recycling process must be regulated to ensure proper decontamination procedures are followed. Moreover, maintaining the high-performance functionalities of these materials necessitates chemical recycling, which is an energy-intensive process. Consequently,

[64] There are actually some exceptions for military purposes, such as lead chemicals. See: https://www.psmagazine.army.mil/News/Article/2567624/get-the-lead-outnot/

the cost of recycled materials may not be competitive with raw materials sourced outside Europe.

2.3 Recommendations for future policy action

Following the review of existing strategic and policy documents for the textile ecosystem and interviews with stakeholders, the following preliminary recommendations have emerged:

- **Improve market surveillance activities**. In its position paper “Trade Policy” (2020), Euratex suggests that to ensure that imported textile products comply with EU legislation, under the Intellectual Property Action Plan, the Commission should support Member States’ customs authorities in improving customs control by reinforcing customs risk management. Intellectual property rights also have to be strengthened at the WTO level and in the framework of Free Trade Agreements (FTAs). A critical angle of FTAs is the implementation and enforcement phase. The EU should guide and support Member States in equipping their market surveillance apparatus with sufficient resources and skills to effectively perform their tasks.
- **IP (Intellectual Property Rights) supports the fostering of innovation sovereignty**. SMEs do not typically see the use of IP systems as a benefit but instead as a challenge, as they find its procedures very costly and they lack the necessary expertise. It is important to provide them with tailored information and resources to help companies deal with IPR. Awareness-raising campaigns about the benefits of IP and intelligence on international and national IP law are also of utmost importance for the sector.
- **Increase awareness of funding opportunities for textile SMEs and introduce dedicated support programmes.** According to interviewees, insufficient public funding is targeted specifically at textile operators, which limits their access to public funding. Moreover, existing funding opportunities for the textiles ecosystem should be better communicated to increase awareness.
- **Financial support for the green transition**. Several stakeholders have emphasized the need for financial support to aid SMEs in their transition to greener operations and to help them navigate a challenging market environment. This support should address capital expenditures (Capex) and operational expenditures (Opex) to equip these businesses with the necessary resources for sustainable upgrades and ongoing operational costs.
- **Disseminate knowledge about implemented measures among different levels of authorities.** In the case of green procurement, the central government should actively promote communication campaigns aimed at regional and local authorities responsible for issuing tender procedures. This approach ensures that all parties are well informed about the latest standards and practices, facilitating a cohesive and effective implementation of green procurement policies throughout the governmental hierarchy.
- **Enhance market intelligence**. During interviews, stakeholders reported a lack of information on the technical textile value chain. They claim a lack of data regarding the companies operating within this value chain and their actual production capacity. This information is crucial to gather before designing any OSA-oriented policy. One stakeholder emphasized that failing to certify the supply chain after the pandemic and not understanding which companies invested and how the supply chain evolved represented a missed opportunity for the industry. During the pandemic, many companies obtained certifications and numerous certification laboratories were established, investing in testing machinery that had previously been outsourced abroad.

- **Support alternative and sustainable consumption models**, such as substituting disposable medical equipment like gowns with reusable products. This would help the EU reduce its import dependency on extra-EU products. It would also positively impact EU SMEs, providing them with opportunities for innovation and market growth in the production of reusable medical equipment.
- **Maintain a long-term outlook to establish enduring leadership in the sector,** as demonstrated by the failure of the attempt to increase face mask production capabilities during the COVID-19 pandemic.

3 OSA and SMEs in the health ecosystem

Highlights:

- Active Pharmaceutical Ingredients (APIs) are the building blocks of all pharmaceutical products. API production in the EU is concentrated in Italy, Germany, France, Spain, and Ireland. Since the 2000s, competitors from China and India have emerged, challenging the global leadership of the EU, USA, and Japan across various pharmaceutical sectors.
- SMEs account for 86% of firms in the pharmaceutical sector, and most of them are active upstream (R&D and innovation activities) and in the middle of the value chain (production of intermediates and APIs).
- Around 50% of the SMEs in the sector are controlled, partially owned by or in exclusive licensing agreements with larger firms. Around 20% of independent SMEs produce APIs.
- In this domain, increasing OSA would entail bolstering API manufacturing in the EU and onshoring certain types of API production. Some Member States (France and Austria) have already taken action in this direction.
- Increasing OSA manufacturing in the EU can create new market opportunities for SMEs, especially regarding the development and production of niche products.
- Some already existing policy interventions targeting SMEs can be found in the field of innovation policies. The European Medicine Agency offers important financial and advisory support to SMEs on a variety of issues.
- While there might be opportunities for SMEs, the extent of these opportunities in a market predominantly controlled by major corporations is uncertain and still being investigated.

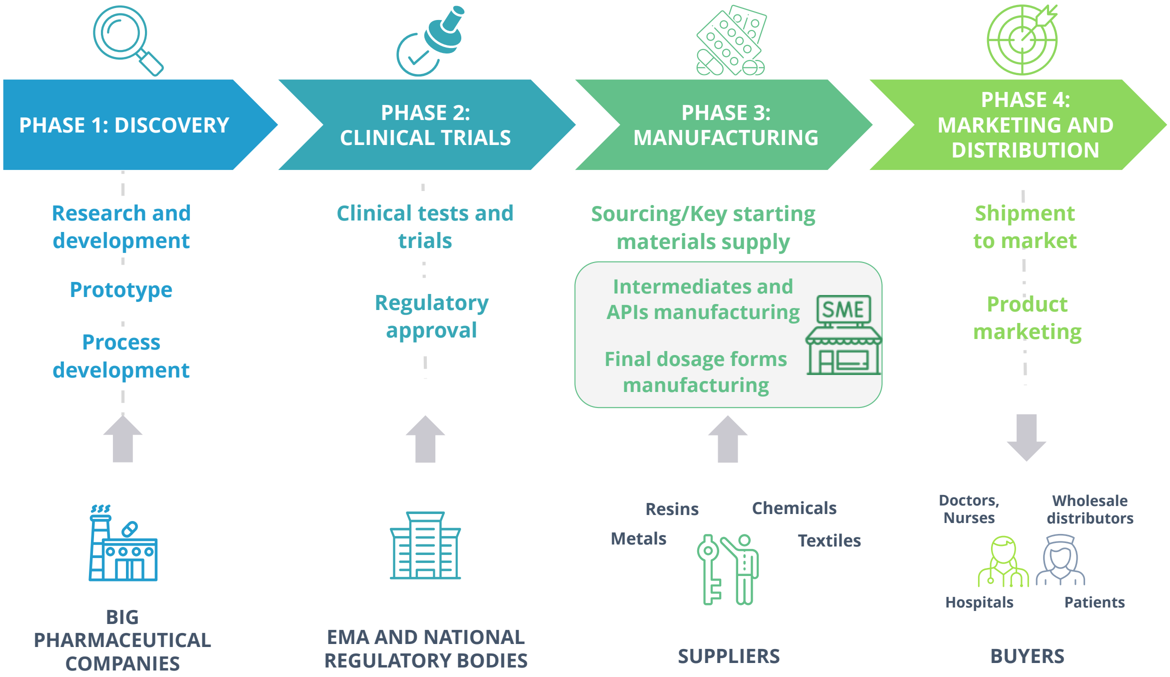
3.1 Overview of the value chain, positioning of SMEs and strategic vulnerabilities

This section offers an overview of the main issues related to OSA and SME development in the Health ecosystem. More specifically, the focus is on **Active Pharmaceutical Ingredients (APIs)**. These are the **building blocks of all pharmaceutical products** and the most vulnerable commodity within the ecosystem.

Four main stages characterise the pharmaceutical value chain. The first relates to the discovery of a new drug as a result of R&D activity. Second, the drug needs to be approved through clinical trials (2-stage) before production can start (3-stage). The final stage is then the marketing and distribution of the finished dosage forms (FDFs). APIs – for example, paracetamol, heparin, ibuprofen, or amoxicillin – enter the pharmaceutical global value chain (GVC) during the third stage as the supply of key starting materials. The production of intermediaries and APIs is essential to have FDFs.[65]

[65] The pharmaceutical GVC may differ according to the type of drug considered. Indeed, the value chain is shorter in the case of generics or already discovered drugs.

Figure 11. Value chain of new pharmaceutical products



Source: Authors

Since the early 2000s, two major transformations have shaped the pharmaceutical sector worldwide.[66] On the one hand, generic pharmaceutical products have been subject to **price pressure owing to increased competition from China and India**. The latter have benefitted from scale effects, lower wages, lower environmental regulations and industrial policy support. European buyers' behaviour also focused on price and quality while disregarding other factors like environmental and labour standards. On the other hand, the industry has undergone the so-called **financialisation wave**, that is, the finance sector – in the form of banks, asset management firms, venture capitalists and hedge funds – entering the ownership structure of pharmaceutical businesses and determining a shift towards an emphasis on shareholder value, and hence profitability, in decision making.[67]

At the European level, **APIs production is mainly concentrated in Italy, Germany, France, Spain, Ireland and the Netherlands**. Germany, France and Italy are countries with long-lasting industrial traditions in the chemical and pharmaceutical sectors.[68] During the twentieth century, the industry expanded to other European countries. In particular, the creation of the Single Market after 1992 seems to have played a significant role in promoting the expansion of the pharmaceutical industry in other EU Member States, especially those where the labour cost was lower.[69] As a result, nowadays, APIs production takes place in almost all European countries, although to very different extents. Industrial capacity may substantially expand to other MS. However, the lack of a skilled workforce represents an obstacle to this expansion. At the same time, non-EU API manufacturing, which used to be mostly in the USA and Japan,

[66] Grumiller, J., Grohs, H., & Reiner, C. (2021). *Increasing resilience and security of supply production post-COVID-19: from global to regional value chains?. Case studies on medical and pharmaceutical products.* OFSE Research Report, 76;
European Parliament (2021) Post Covid-19 value chains: options for reshoring production back to Europe in a globalised economy. https://www.europarl.europa.eu/RegData/etudes/STUD/2021/653626/EXPO_STU(2021)653626_EN.pdf

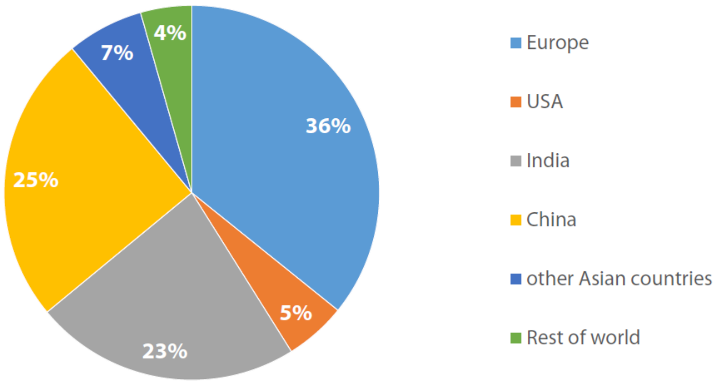
[67] Busfield, J. (2020). Documenting the financialisation of the pharmaceutical industry. *Social Science & Medicine*, 258, 113096.

[68] The first chemical APIs to be discovered were salicylic and acetylsalicylic acid, developed by a French and German chemist respectively.

[69] Ruane, F., & Zhang, X. (2007). *Location Choices of the Pharmaceutical Industry in Europe after 1992*. IIIS Discussion Paper n. 220.

since the 2000s has seen gains by China and India that are now contending for global leadership in a variety of pharmaceutical sectors.

Figure 12. Distribution of API manufacturers by geographical region



Source: van der Hoven (2020). *Practical measures are paramount for robust medicines manufacturing*. PHARMAnetwork magazine, n. 46 (89054686-d316-4e12-b702-53ecb21bd476.pdf (medicinesforeurope.com))

SMEs play an important role in the European manufacturing of pharmaceutical products. Eurostat data shows almost 3,600 SMEs in the sector, accounting for **86% of firms**[70]. Along the value chain, their involvement is particularly relevant in the manufacturing of APIs and FDFs, i.e., the central stage of the process.

In this respect, it is worth noting that the financialisation of the pharma sector had important consequences for the involvement of SMEs in manufacturing APIs and FDFs in general and for their ownership structure. Many large firms seeking to maximise shareholder value have started to subcontract to SMEs at some stages of the value chain, in particular, low value-added processes. As a result, **many SMEs are now either controlled or partially owned by large firms or engaged in exclusive contractual agreements with them**. Although they can be considered formally stand-alone firms, they are not entirely independent when it comes to decision-making. Therefore, according to the European Commission guidelines,[71] when assessing the size of these firms, one needs to consider the headcount as well as the turnover of the controlling firm. Many businesses with low turnover or few employees do not, therefore, fully qualify as SMEs. As a result, figures presented by Eurostat may overestimate the importance of SMEs in the sector.

An additional source of information to more precisely quantify the SMEs' engagement in the pharmaceutical sector is the SME register compiled by the European Medicine Agency (EMA).[72] Application to the register is made on a voluntary basis, and to have access, firms need to demonstrate their SME status according to the Commission guidelines, that is, taking into account headcount and turnover of the controlling firm – if relevant. This means that SMEs appearing in the register can be considered independent entities. According to 2022 data, almost 2,000 SMEs are registered, that is, around 55% of the businesses reported in Eurostat are not controlled by a larger firm. The SME definition has paramount importance when it comes to access to public subsidies or intervention since SMEs partially owned or controlled by larger firms are not eligible for public support. Notably, among the 2,000 SMEs reported in the EMA register, **21% are engaged with the production of APIs and around 50% are chemical entities**.

[70] Structural Business Statistics, Eurostat available at https://ec.europa.eu/eurostat/databrowser/view/sbs_ovw_act/default/table?lang=en&category=bsd.sbs.sbs_ovw

[71] https://ec.europa.eu/docsroom/documents/42921

[72] SMEs entering the register are entitled to have access to the services provided by EMA. For more details, see https://fmapps.ema.europa.eu/SME/aboutus.php

In terms of market dynamics, feedback from interviews points out that well-established firms dominate the APIs industry**, whilst start-ups are a few**. Indeed, the start of a new APIs production requires huge investments in infrastructure and access to such funding is not always ensured by the market conditions. The process takes several years to become productive and profitable, whilst institutional investors and public funding envisage shorter support.

Interviewees say that **APIs producers find it difficult to innovate because of the regulatory burden**. Any innovation regarding existing molecules, be it substantial or minimal, at the product or at the process level, must be notified and approved by the relevant authority, e.g. national medicine authorities and European Medicine Agency (EMA). Upon approval, the medicine dossier needs to be updated in all the countries where the product is commercialised, implying an onerous administrative burden which eventually tends to discourage companies to pursue innovation.

The profound transformations that shaped the pharmaceutical sector since the 2000s also brought about significant changes in the EU's – and the US's – dependency on external APIs producers. The lower production costs and the more favourable regulatory environment of Asian firms[73] meant European and USA pharmaceutical industries started to rely heavily on external APIs suppliers. Even when production was retained in Europe, Chinese and Indian firms were the primary sources of APIs precursors. Consequently, Europe increasingly depends on imports from Asia for a consistent number of APIs and precursors.[74] It is estimated that the direct and indirect dependency on Asia is around 74% of the total market value.[75] According to a recent study,[76] there is no longer European production capacity for around 20% of the APIs analysed.

However, as Figure 13 suggests, **vulnerability is very much nuanced with respect to the type of APIs considered**. For some APIs like Simvastatin – used in the treatment of high cholesterol – there is total dependence from Asia, whereas in the case of Methotrexate – used to treat inflammatory conditions such as arthritis, psoriasis and some types of cancers – the vast majority of the manufacturing happens in Europe.

---

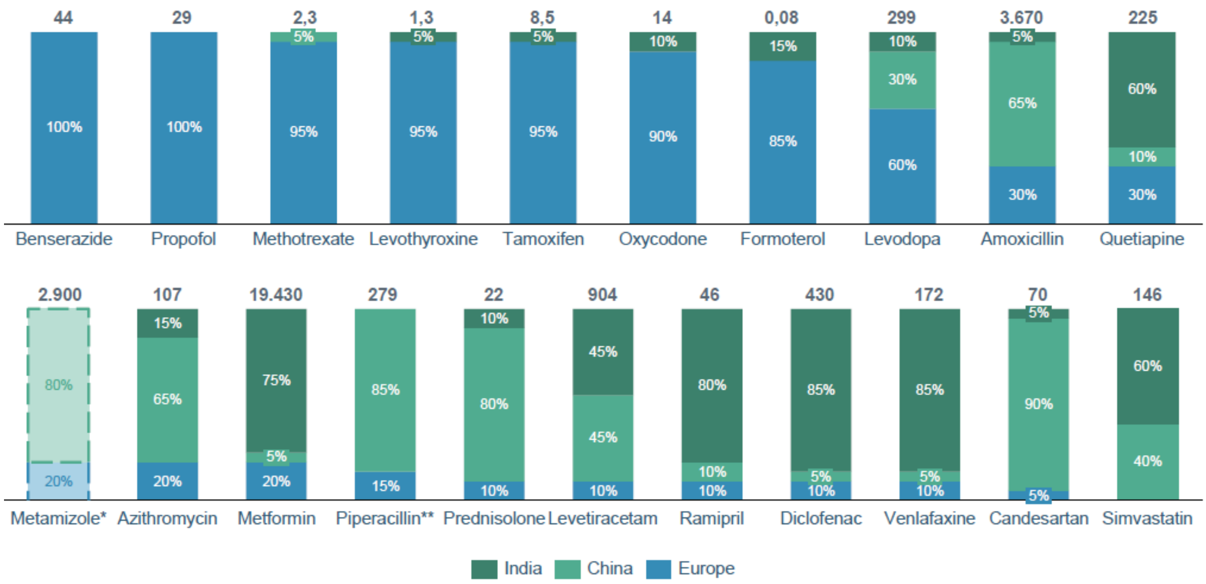
[73] It has been estimated that investment and operating costs in Asia are on average 20-40% lower than in Europe. See *Study of API supply vulnerabilities for the European pharmaceutical industry* – Final Report. SICOS, LEEM, G5 Santé, PwC Analyses Strategy& study, July 2021. https://chimiefine-biochimie.fr/IMG/pdf/20210730_-_sicos_leem_gemme_-_study_of_api_supply_vulnerabilities_for_the_european_pharmaceutical_industry_-_final_report_en_20210907.pdf

[74] European Commission Staff Working Document, 2022. Vulnerabilities of the gloabl supply chains of medicines. https://health.ec.europa.eu/system/files/2022-10/mp_vulnerabilities_global-supply_swd_en.pdf

[75] *EU Fine Chemical Commercial KPI*. IQVIA study, December 2020. https://efcg.cefic.org/wp-content/uploads/2021/06/20201211_IQVIA-for-EFCG_Executive-summary.pdf

[76] *Where do our active pharmaceutical ingredients come from? A world map of API production.* Pro Generika study, September 2020. https://progenerika.de/app/uploads/2020/11/API-Study_long-version_EN.pdf

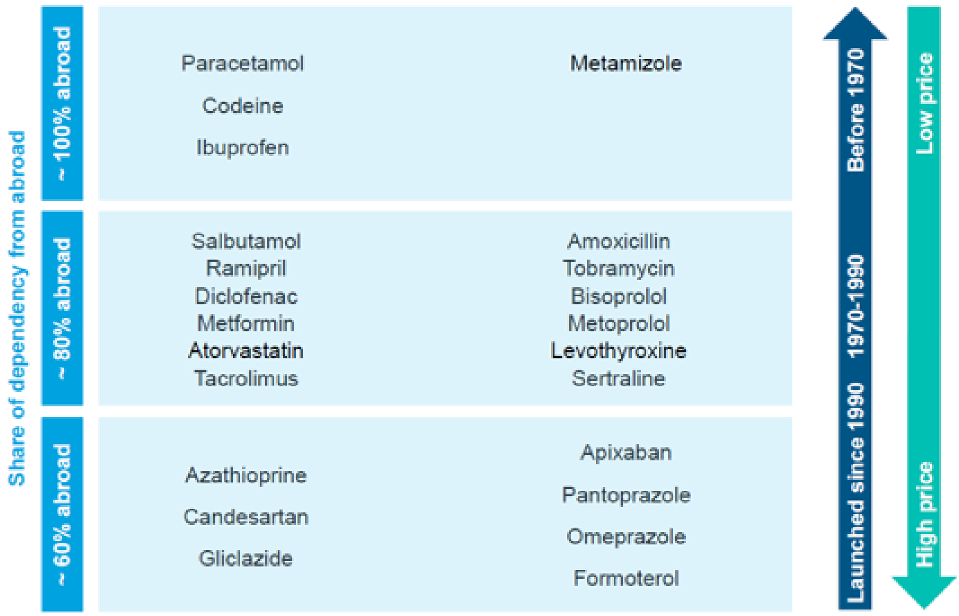
Figure 13. Share of some selected API supply in percentage by region of origin



Source: Where do our active pharmaceutical ingredients come from? A world map of API production. Pro Generika study, September 2020.

More generally, China and India are specialised in the production of high-volume and low-margin APIs and **Europe relies heavily on Asia for the supply of generic, relatively old and low-price APIs**. An extreme case is paracetamol, for which no production plant currently exists in Europe. The dependence decreases as one moves towards newer and higher price APIs, or when highly specialised and complex products (Figure 14).

Figure 14. Mapping of the most relevant APIs for the EU based on their level of foreign dependency, price and seniority in the market



Source: *EU Fine Chemical Commercial KPI*. IQVIA study, December 2020

A recent study has singled out five main **market failures** at the basis of the EU APIs production dependency and vulnerabilities, which should be considered when investigating the role played by SMEs or their future opportunities in this field.[77]

- **The supply of inputs is fragile** since inputs and precursors for certain types of APIs are almost exclusively manufactured outside the EU. This is the case of heparin, for example. China is the leader in the production of heparin and its precursors because it has the largest livestock and consumption of swine in the world.[78]
- **The production of APIs is complex.** Some APIs are produced following processes that may be unstable because of specific synthesis routes or low yields; alternatively, the production processes may entail many manufacturing steps, or they may need to comply with stringent standards. The complexity of production results in high labour costs and significant production constraints that hamper European firms' competitive position with respect to Asian markets.
- **The production of APIs produces pollutants that must be treated.** Manufacturing certain APIs generates dangerous waste products that must be properly treated so as not to damage the environment. As EU regulation is stringent in this field, production costs are almost 30% higher than those facing Asian competitors. EU competitiveness is also strongly impacted because EU environmental regulation applies only to European production and not imports.
- **The price of APIs is low**. Several APIs are high volume and very low priced. This is the case, for example, for paracetamol or statins – used to treat cholesterol-related diseases. Given the low value, the production of these APIs has been moved to countries with low structural costs that enable economies of scale, or with privileged access to critical input (which again reduces costs). Innovation would be needed to escape the low value-economies of scale spiral.
- **The demand for the APIs is unstable**. APIs used mainly for the manufacturing of medicines provided in the hospital environment are characterised by an unstable consumption pattern. Therefore, producers are not able to plan production in the long term and thus benefit from economies of scale. This, in turn, makes their production rather economically unsustainable.
- An additional remarkable market failure is that Europe is lagging **in innovation related to APIs** and pharmaceutical products in general. Although the pharmaceutical sector is the EU industry with the highest level of R&D per employee, the amount of R&D spending has steadily decreased since early 2000. According to 2020 figures, while in 2000 the difference in R&D expenditure between USA and EU firms amounted to EUR 2 billion, the difference in 2020 had increased to almost EUR 25 billion.[79] China and India are also increasing their private expenditure in pharmaceutical R&D at a much higher pace than Europe.[80]

[77] Study of API supply vulnerabilities for the European pharmaceutical industry – Final Report. SICOS, LEEM, G5 Santé, PwC Analyses Strategy& study, July 2021. https://chimiefine-biochimie.fr/IMG/pdf/20210730_-_sicos_leem_gemme_-_study_of_api_supply_vulnerabilities_for_the_european_pharmaceutical_industry_-_final_report_en_20210907.pdf

[78] Grumiller, J., Grohs, H., & Reiner, C. (2021). *Increasing resilience and security of supply production post-COVID-19: from global to regional value chains?. Case studies on medical and pharmaceutical products.* OFSE Research Report, 76;.

[79] Erixon, F., & Guinea, O. (2023). *Strategic Autonomy and the Competitiveness of Europe's Innovative Pharmaceutical Sector: A Wake-up Call.* European Centre for International Political Economy (ECIPE).

[80] SICOS, LEEM, G5 Santé, PwC Analyses Strategy& study (2021)

3.2 OSA goals and overview of relevant policy initiatives

The European Commission in the communication "Pharmaceutical strategy for Europe"[81] in 2020 recognised the **importance of adhering to the principles of OSA in the medicines sector** to enhance the supply chain's resilience and avoid shortages.

Box 9: OSA and the Pharmaceutical Strategy for Europe

The Communication on Pharmaceutical Strategy presented some flagship initiatives in the spirit of the Open Strategic Autonomy paradigm including:

- a proposal to revise the pharmaceutical legislation to introduce mechanisms that would increase the ability of the EU to monitor, manage and avoid shortages, like, for example, implementing a system of early-warning notifications of shortages;
- the launch of a structural dialogue with and between the main actors in the pharmaceutical value chain and public authorities. The aim is to bring together specific knowledge on the global supply chain and to identify vulnerabilities regarding critical medicines, raw pharmaceutical materials, intermediates and APIs;
- proposed voluntary actions to increase the transparency of the supply chain.

Source: Authors

In 2023, the Spanish presidency of the European Council, in close consultation with officials of the 27 Member States, narrowed down the scope of these initiatives, pointing to the **enhancement of the internal productive capacity** as the way forward in tackling vulnerabilities and dependencies in the pharmaceutical sector. API manufacturers should be supported in enhancing all medicine production in Europe. The presidency identified the production of antibiotics, anaesthetics, haematological, oncological medicines, and vaccines as the priority, as well as the manufacture of less profitable drugs. The Belgian presidency has taken up the baton from the Spanish and has added the pursuit of "health sovereignty" among its main goals.

As a concrete first step towards the goals presented by the Pharmaceutical Strategy and according to the line of action put forward by the Spanish presidency, in October 2023, the European Commission published the communication "Addressing medicine shortages in the EU". This contains several initiatives to address shortages in the EU, especially regarding critical medicines.[82] Among them, many are APIs. The structural measures proposed have been acted upon by the establishment of the "Critical Medicine Alliance". This was launched in January 2024 and is meant to develop recommendations and provide advice to the Commission, the Member States and EU institutions on an industrial strategy geared to tackle medicines shortages. The starting point of the Alliance was the publication of the "Union list of critical medicines" by the EMA in December 2023. This lists all the pharmaceutical products with the highest risk of facing shortages and the highest impact on healthcare. The Alliance should have an important impact on defining future policies in the OSA domain, especially regarding the coordination of policies aimed at boosting the European capacity to produce and innovate in the manufacture of critical medicines and their ingredients.

[81] https://health.ec.europa.eu/system/files/2021-02/pharma-strategy_report_en_0.pdf

[82] It has to be noted that in the Commission view "critical" is not a synonym for "vulnerable" in the OSA terms, i.e. not all the medicines classified as critical suffer also for external dependencies that have to tackled through OSA policies.

Besides presenting strategies and future initiatives, **some concrete interventions have been made by single Member States, especially along the lines of – at least partially – reshoring certain types of production** (Table 4).

Table 4. Overview of initiatives to promote APIs production in Europe

Initiative	Overview	Country	Year	API/medicines affected	Stakeholders involved	Core nature of incentive/ measure	Public resources spent
Kundl (Novartis/Sandoz)	Plant in Kundl (Tyrol)	Austria	2021	Penicillin	Novartis/Sandoz; Austrian government	Subventions by state	EUR 50 million (EUR 100 million from industry)
EuroAPI (Sanofi)	Founding initiative for a European API production company	France	2021	Steroids; alkaloids; sartans; antihistamines; antipyretics; vitamin B12; anti-infectives; prostaglandins	Shareholders: Sanofi (30,1%); EPIC Bpifrance (12%); L'Oréal (5,5%); Free float (52,4%)	Share (12%) by state investment bank Bpifrance (through "French Tech Souveraineté")	Unclear
Sequens	Enlargement of the portfolio with co-funding by the French government	France	2022	Paracetamol; others	Shareholders: SK Capita; Bpifrance; Nov' Santé Actions Non Cotées; Mérieux Equity Partners; Ardian; Eximium	Subvention by state investment bank Bpifrance	EUR 94 million in 2021

Source: Authors' elaboration, based on European Parliament (2021), *Post Covid-19 value chains: options for reshoring production back to Europe in a globalized economy*.

Moreover, in June 2023, EuroAPI – the French company founded in 2021 as a result of the initiative described in the previous table and that is leading the market for small molecules APIs – announced additional initiatives to increase the production capacity of several APIs that have been listed as essential medicines by the French authorities. More specifically, Francopia – a subsidiary of EuroAPI – will invest in R&D at the Vertolayne site to develop an innovative morphine and derivatives production process that could increase productivity and shorten the industrial cycle to help build up strategic stocks. The investment will amount to almost EUR 70 million, which the French state will partially fund via the France2030 spending.[83]

There are other initiatives involving the pharmaceutical value chain, but they are mainly private efforts or unrelated to API production per se. Among the latter is the "Lighthouse Project – Industry 5.0" in Ireland – funded in part by the Irish government – and doing research in innovating manufacturing processes.

The reshoring of APIs manufacturing may represent an opportunity for SMEs. Indeed, according to the experts interviewed so far, large firms may have little or no interest in investing in the manufacture of low-volume and niche products that do not offer economies of scale. This, then, could be a part of the market that is more suitable for SMEs and where they can make a difference. Moreover, the choice of focusing on niche products would protect SMEs from the possible risks entailed in the reshoring of APIs. Indeed, the reshoring would only be possible if the market is willing to accept higher prices for APIs. The risk would be particularly

[83] https://www.euroapi.com/en/health-sovereignty-EUROAPI-supports-the-supply-of-essential-medicines-to-France-and-Europe. France 2030 is a funding programme established in 2010 by the French government to stimulate employment, boost productivity and increase competitiveness of French businesses by encouraging investment and innovation in priority sectors.

severe for large volumes of relatively low-priced APIs. Low-volume, high innovative APIs might be less risky since they are generally recognised – even from the public – as more valuable.

Interventions directly targeting SMEs are more often found in the field of innovation policies. The following initiatives could be relevant:

- **Horizon Europe (HE) cluster 1 initiative**, which is dedicated to health and aims at supporting research and promoting innovative and high-quality health technologies-
- The **European Investment Bank support to the life science sector**, which focuses on the venture debt instrument targeting innovative SMEs.
- **Hera Invest fund**, created by DG HERA in collaboration with the EIB. The main goal is to promote R&D to strengthen strategic autonomy, and it targets SMEs involved in the development of medical countermeasures addressing specific health threats such as antimicrobial resistance.

Building on innovation subsidies, SMEs may play an important role in bridging the innovation gap that is widening between Europe and other developed and developing countries. Enhancing their innovativeness can increase their market value and hence attract external investors who would, in turn, contribute to further sustaining innovation, thus creating a virtuous circle. Feedback from interviews points out that besides product innovation – e.g., the development of new molecules – it would be imperative to incentivise process innovation. The latter would directly tackle one primary source of dependency from Asian countries, and it would be an area where SMEs could significantly contribute.

SMEs operating in the pharmaceutical sector may also receive support from the EMA, according to Commission Regulation 2049/2005. Indeed, the Agency is entitled to offer technical and financial support to SMEs in the pharmaceutical sector with the aim of promoting innovation and the development of new medicinal products by SMEs (Box 10).

Box 10: Services offered by the EMA SME Office

- Financial fee incentives: fee exemptions and reductions for pre and post-authorisation regulatory procedures (e.g. inspections, post-authorisation procedures) and pharmacovigilance activities;
- Regulatory assistance services: direct assistance on regulatory, administrative and procedural topics;
- Support for EMA's clinical data publication (Policy 0070): guidance on clinical data publication and free redaction tool license;
- SME briefing meetings: early dialogue to discuss the regulatory strategy for human or veterinary medicinal product development and how to navigate the range of procedures and incentives available;
- Support for Priority Medicines Scheme (PRIME): pre-submission support on the PRIME scheme;
- Translation assistance: free of charge translation of the product information in the EU official languages required to grant an initial EU marketing authorisation;
- Advanced therapies incentives (certification): enables early review of quality and non-clinical data of ATMPs and allows a developer to confirm the extent to which the available data comply with the standards that apply for evaluating a dossier;

- Public SME register: public source of information on EU/European Economic Area-based SMEs involved in the manufacture, development and/or marketing of human and veterinary products;
- Training events: free of charge regulatory training courses dedicated to addressing the particular needs of SMEs;
- SME User Guide: provides an overview of procedures to support research and development activities and improves understanding of what is needed to obtain marketing authorisation;
- SME newsletter: circulated regularly and published on the EMA website to provide highlights, news, documents and information on activities on the EU regulatory environment for medicines.

Source: Outcome of SME office survey on the implementation of the SME regulation - Commission Regulation (EC) No 2049/2005, https://www.ema.europa.eu/en/about-us/support-smes/sme-regulation-and-reports.

The APIs industry suffers from a shortage of skilled workforces, just as many other sectors do. There are several initiatives specifically targeting the health ecosystem within the Pact4Skill. However, feedback from interviews points out that some structural hurdles are still present, such as a lack of coherence in health-related curricula across Europe. Moreover, interviewees noted that the lack of skilled people is one of the factors that hamper the possibility of expanding the APIs industrial capacity beyond the countries that have traditionally been involved in this production.

The USA and Europe share concerns regarding the manufacturing of APIs. According to a recent White Paper from the API Innovation Center of St. Louis,[84] over the past decade, Asian countries have seen a significant increase in API production facilities, whereas the US has experienced a nearly 60% reduction. The paper attributes the decline in the US to low profit margins on APIs, which discourage investment in new facilities and advanced manufacturing technologies. It suggests that while nearshoring could be a solution, public incentives are crucial to encourage manufacturers to adopt innovative manufacturing techniques.

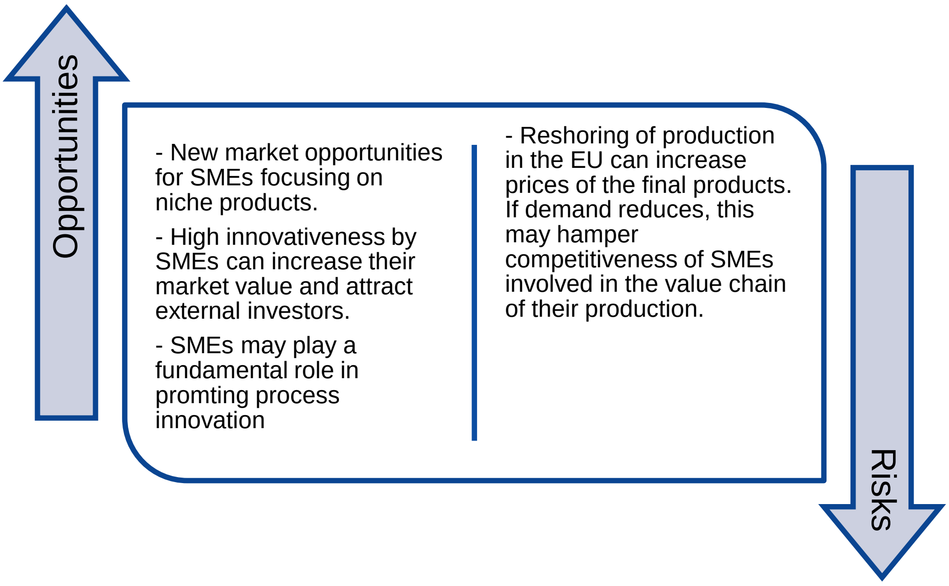
China's pharmaceutical industry grew significantly during a period of relative international isolation, primarily meeting domestic needs. With the transition from a centrally planned to a market-based economy, the sector expanded rapidly, mainly thanks to generous government incentives and the creation of the so-called special industrial zones.[85] As China became a major global player, especially in the production of active pharmaceutical ingredients (APIs), regulatory issues emerged, affecting both international and domestic markets. To align with international standards, the Chinese government implemented huge regulatory changes that have led the country to a very stringent drug approval process and environmental legislation. Both negatively impact the economic viability of smaller, less well-capitalised companies as regulatory compliance is increasingly costly.

---

84 https://apicenter.org/news-updates/white-paper.

85 https://www.who.int/publications/i/item/9789241512176.

Figure 15. Opportunities and risks for SMEs from higher strategic autonomy in API production



Source: Authors

3.3 Recommendations for future policy action

Some recommendations for future policy action can be identified from the results of the interviews. As a general remark, the experts point out that since there is a variety of market failures at the root of European dependencies and vulnerabilities, the promotion of domestic APIs production would require a holist approach comprising both **industrial policy measures – in the form of subsidies or tax incentives – and regulatory measures** to influence institutional procurement behaviour.

In this respect, almost all interviewees point out that a major change in the procurement model would be needed to make the reshoring of API production viable. SMEs producing APIs may have the financial capacity to invest in process innovation or in new molecules, but they would need to know that there will be a market for their products. The creation of this market opportunity requires rethinking the procurement process. In particular, two features of the latter would need a change. First, procurement should go beyond the "winner takes it all" scheme to promote a multi-tendering process by which several companies of different sizes contribute to the tender. Second, the tendering process should not be based only on the price component, as it should valorise the product's compliance with European labour and environmental standards.

Relocation of production in the EU entails the willingness of public institutions to accept higher APIs prices. APIs producers may have their own financial capacity to invest in reshoring the production of certain APIs. However, they would need to be guaranteed access to certain market shares. The latter could be achieved through the willingness of public institutions to pay higher rates.

Fast-track approvals for companies choosing European APIs suppliers should be envisaged. A pharmaceutical company that wants to switch from an Asian to a European APIs supplier to manufacture its drug has to go through a heavy administrative procedure. Indeed, any change regarding the suppliers of the drug's ingredients as well as any other change concerning the production process, need to be certified by the competent authority. The notification implies a long paperwork, which might finally discourage the company from switching suppliers. Adopting fast-tracks for companies that decide to refer to European producers may incentivise the change and would be particularly beneficial for SMEs.

SMEs involved in APIs manufacturing may greatly benefit from collaboration with universities and research institutions to be up-to-date with innovative solutions. Many SMEs involved in manufacturing – i.e., not explicitly focused on innovation – are not capable of setting up sufficiently large research departments to conduct research and development activities. Moreover, applying to European programmes promoting innovation is difficult for them. Collaborating with universities and research institutions may help them fill this gap and keep their business up to the innovation frontier.

Focusing on SMEs, it has been claimed that training SMEs on the gaps in the pharmaceutical market would be important to position themselves where the chances of success are the highest. The aim of such training would be to illustrate the opportunities that the market offers and the area where SME contribution would be essential because large firms have little or no interest.

Regarding the skills needed to bolster the EU production of APIs, interviewees signal that **authorities in charge of designing health-related curricula should coordinate to have such curricula coherent across Europe**. This would enhance the chances of recruiting workers from other EU countries. Moreover, European apprenticeships and workers exchange programmes should be promoted.

4 OSA and SMEs in the electronics ecosystem

4.1 Microelectronics

Highlights:

- The semiconductor industry is among the most upstream industries, where semiconductors are an important input into production in ICT and electronics, machinery, motor vehicles, and other transport equipment.[86]
- The semiconductor industry is geographically highly concentrated, with a marked shift towards China, South Korea and Taiwan, which accounted for approximately 60% of global semiconductor-added value in 2018. Dependency in the USA and the EU are driven to a larger extent by the needs of the "transport equipment", "machinery", and "other manufacturing" industries. The concentration of production for some specific semiconductors, such as memory chips and certain capital goods used in semiconductor production (e.g., specialised machinery and equipment), is often highlighted as the source of vulnerability.[87]
- Strong semiconductor ecosystems are present in Germany, Belgium, Italy, France, Austria and Finland. Microelectronics clusters are also in Ireland (which hosts Intel's largest Fab outside the US with advanced node manufacturing capability) and Greece.
- The EU and MS enable large investments through Important Projects of Common European Interest (IPCEI) and other funding programmes, which often require SMEs to be included. The selected projects include the production of materials, chip design, semiconductor production, and integration into components and systems.
- The EU Chips Act and Chips for Europe Initiative are investing EUR 11 billion in public investment until 2030 from the European Union and MS. This funding also includes significant private investment leverage. The initiative will be implemented through Horizon Europe and Digital Europe, where the former focuses on precompetitive research, technology development, and semiconductor and materials innovation.
- SMEs feature in different parts of the supply chain for microelectronics as suppliers to larger manufacturers, end users, as well as machinery suppliers.
- SMEs and other companies benefit from the clustering in the microelectronics sector due to several factors:
    - Interaction between universities, research centres, and industry within joint projects and initiatives.
    - Proximity between different stages of the development process as well as end-users, which supports a closer link between supply and demand.

---

86 Haramboure, A., et al. 2023. "Vulnerabilities in the semiconductor supply chain", OECD Science, Technology and Industry Working Papers, No. 2023/05, OECD Publishing, Paris. Available at: https://doi.org/10.1787/6bed616f-en. Accessed: 10 April 2024, pp. 5-6.
87 *Ibidem*

- Sharing of resources and in particular access to cost-effective pilot lines, fabs, small batch facilities, which are targeted to SMEs.
- Support from regional and national authorities to pursue strategic initiatives.

4.1.1 Overview of the value chain, positioning of SMEs and strategic vulnerabilities

This section focuses on the microelectronics industry in the electronics ecosystem. The definition of microelectronics can vary, but broadly, it can be defined as "**electronic devices manufactured using semiconducting materials**".[88] A chip is a "set of miniaturised electronic circuits composed of active discrete devices (transistors, diodes), passive devices (capacitors, resistors) and the interconnections between them, layered on a thin wafer of semiconductor material, typically silicon".[89] Although semiconductors and their production form the technological basis of microelectronics, the terms microelectronics, semiconductors and chips are sometimes used interchangeably.[90] A recent report outlines that the global supply chain enabling technological progress is "remarkably complex, segmented, and international".[91]

Microelectronics are a critical enabling technology strategically crucial for the EU's industrial future for several reasons (Box 11).[92] They enable the creation of electronic devices and systems and are, therefore, integral to a wide range of applications and emerging technologies, including telecommunications, computing, consumer electronics, automotive systems and autonomous vehicles, AI, IoT, augmented reality, medical devices, and more.[93] Microelectronics also play a crucial role in national security due to their use in defence systems, communication networks, intelligence gathering, and encryption technologies.[94]

Box 11: Photonics

Photonics, the science of light, is a cross-sectional technology that serves many markets and applications, and photonics technologies, components, and solutions play a crucial role in many EU strategic value chains has been identified as one of the six *key enabling technologies* of the 21st century.[95]

The photonics industry is also pertinent for this study since it faces several supply chain challenges while SMEs heavily dominate the industry. In 2018, approximately 5000 photonics companies in the EU, mostly SMEs, employed 300,000 people directly. In addition, the jobs of more than 2 million employees in the EU manufacturing sector depend directly on photonics products.[96]

---

88 https://www.bis.doc.gov/index.php/documents/technology-evaluation/3402-section-9904-report-final-20231221/file

89 https://www.semiconductors.org/wp-content/uploads/2021/05/BCG-x-SIA-Strengthening-the-Global-Semiconductor-Value-Chain-April-2021_1.pdf

90 https://publica-rest.fraunhofer.de/server/api/core/bitstreams/4b328df2-5bb9-4fbd-9429-2c8badcf4322/content

91 Thadani, Akhil and Allen, Gregory C. 2023. Mapping the Semiconductor Supply Chain: The Critical Role of the Indo-Pacific Region. CSIS Brief. Published May 30, 2023. Available at: https://www.csis.org/analysis/mapping-semiconductor-supply-chain-critical-role-indo-pacific-region. Accessed: 10 April 2024.

92 European Parliamentary Research Service. The EU chips act: Securing Europe's supply of semiconductors. Briefing. 2022. https://www.europarl.europa.eu/RegData/etudes/BRIE/2022/733596/EPRS-Briefing-733596-EU-chips-act-V2-FINAL.pdf

93 https://digital-strategy.ec.europa.eu/en/library/joint-declaration-processors-and-semiconductor-technologies; https://csconnected.com/media/yq4bkzas/huggins-johnston-munday-xu-the-future-of-europe-s-semiconductor-industry-002.pdf

94 https://citylabs.net/military-semiconductor-applications/

95 https://www.flipsnack.com/photonics21/key-data-market-research-study-photonics-2020/full-view.html

96 EIB (2018). Financing the digital transformation Unlocking the value of photonics and microelectronics. https://www.eib.org/attachments/pj/financing_the_digital_transformation_en.pdf. Also Photonics21 surveys.

A recent survey by PH21/EPIC, which analysed the European photonics industry supply chain, pointed out the following key challenges and vulnerabilities:[97]

- The majority of European photonics companies in the survey face major supply chain issues.
- Almost 90% of EU photonics companies faced disruptions caused by shortages and delivery delays in the global supply chain.
- The key choke points for European Photonics companies on the supply input side are microelectronic and photonic semiconductors, optical components, basic raw materials and equipment.
- EU photonics companies are significantly dependent on suppliers from outside Europe.[98]

One interviewee pointed out that the necessary measures to address these challenges include: (i) Broad MINT talent promotion in the educational system; (ii) IP policies at universities; (iii) Uncomplicated and fast handling of IP litigation; (iv) Deep-tech start-up support and tax breaks for tech companies; (v) Effective and adequate regulatory processes; (vi) Excellent quality of reliable public infrastructure; (vii) Recommendations for smart education and smart specialisation in the European way (counteracted with the Chinese way).

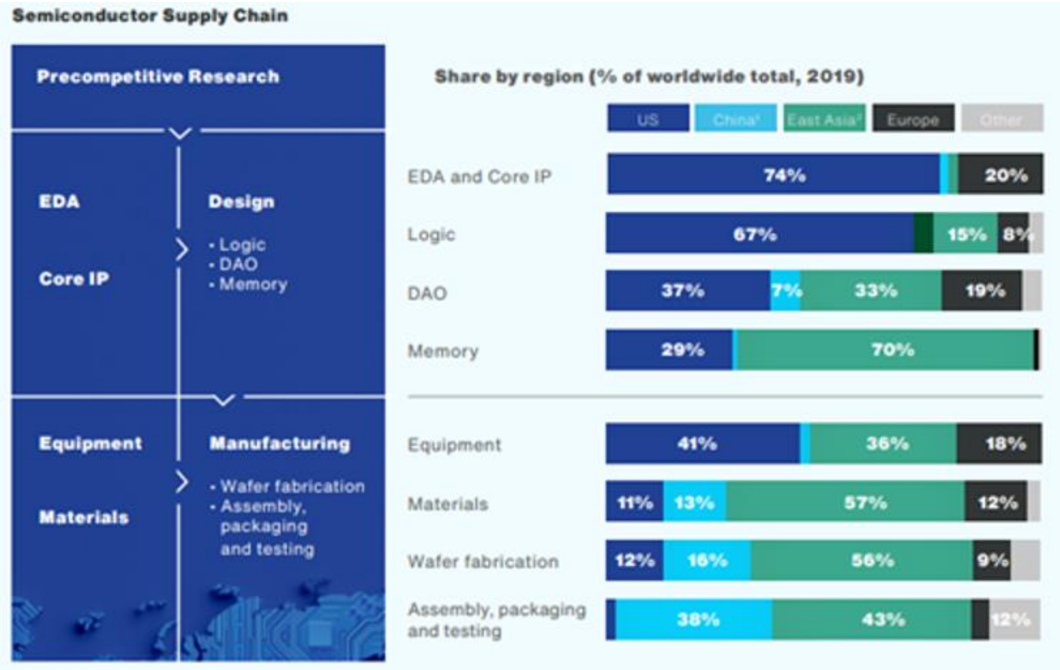
4.1.1.1 Value Chain

To understand the microelectronics supply chain and, consequently, Europe's position in these chains, it is vital to understand the components, categories, technology and equipment associated with semiconductors. Figure 16. The semiconductor supply chain below explains the various stages of the supply chain.

[97] Photonics Industry Supply Chain Survey 2023 Photonics21/EPIC April 2023. https://www.photonics21.org/download/ppp-services/photonics-downloads/230421_Supply_Chain_Report_Final_C3.pdf

98 Photonics21, 2020. New Horizons Securing Europe's technological sovereignty through Photonics Multi-annual Strategic Research and Innovation Agenda of the Horizon Europe Photonics Partnership. Available at: https://www.flipsnack.com/photonics21/photonics21-strategic-research-and-innovation-agenda-2023-2030/full-view.html. Accessed: 10 April 2024.

Figure 16. The semiconductor supply chain



Source: Authors based on BCG and SIA report Emerging Resilience in the Semiconductor Supply Chain[99]

The semiconductor industry is highly capital intensive and requires high investment in R&D. The first important consideration is design activity consisting of electronic design automation (EDA), core intellectual property (IP), and chip design. Another important consideration is equipment and materials. All these are needed to enable the next stage, wafer fabrication. This is followed by assembly, packaging and testing (ATP). There are three categories of semiconductors: logic chips (42% of industry revenue), Discrete, Analog, and Other (DAO) (32% of industry revenues) and memory chips (26% of industry revenues).[100]

A breakdown of the supply chain and Europe's position vis-à-vis the rest of the world is provided here,[101] while MS insights are pro provided in Box 10.

- **Chip Design** relies heavily on advanced **EDA** software and **Core IP**. The EDA software and services are needed to support the design of semiconductors. At the same time, the Core IP is a term used for reusable architectural building blocks licensed by Core IP companies as reusable components. The USA has a clear edge over all other countries in Chip Design as it is responsible for 74% of the chip design. However, Europe takes the second position, with 20% of the EDA and c**ore IP supply chain located here**. The following ongoing initiatives are trying to strengthen the EU's position in chip design:
- **Logic chips** include **microprocessors**, i.e., logic products such as central processing units (CPUs), graphics processing units (GPUs) and application processors (APs) that process fixed instructions stored on memory devices to execute complex computing

[99] Boston Consulting Group (BCG) and Semiconductor Industry Association (SIA) (May 2024). Emerging Resilience in the Semiconductor Supply Chain. Available at https://www.powersemiconductorsweekly.com/2024/05/08/sia-and-bcg-publish-global-chip-supply-chain-report/#:~:text=The%20Semiconductor%20Industry%20Association%20(SIA,)%20was%20enacted%E2%80%94to%202032.

[100] https://www.semiconductors.org/strengthening-the-global-semiconductor-supply-chain-in-an-uncertain-era/

[101] https://www.semiconductors.org/strengthening-the-global-semiconductor-supply-chain-in-an-uncertain-era/

operations; **microcontrollers (MCUs)**, i.e., small computers on a single chip; **General Purpose Logic Products** such as Field Programmable Gate Arrays (FPGAs) that allow a user to program custom logic operations; and **Connectivity Products**, such as cellular modems, WiFi or Bluetooth chips or Ethernet controllers that allow electronic devices to connect to a wireless or wired network to transmit or receive data. **Europe's performance in logic chip design is concerning as it has a share of a mere 8% of the supply chain**, behind the 67% share of the USA and 15% share of East Asia (South Korea, Japan, and Taiwan).

- **DAO** are semiconductors that transmit, receive, and transform information dealing with temperature, voltage, etc. They are categorised as **discrete products** (including **diodes** and **transistors**) designed to perform a single function; **analogue products** (including voltage regulators and data converters) designed to translate analogue signals from sources such as voice into digital signals; and other products such as **optoelectronics** and **actuators** used in IoT devices. Europe's position in DAO design is that **19% of the supply chain is based in Europe, compared to 37% in the USA and 7% in China**.
- **Memory chips** are used for storing information necessary to perform any computation, with two commonly used types: **Dynamic Random Access Memory (DRAM)** used to store the data or program code needed by a computer processor to function, and **NAND** (NOT-AND) used for permanent storage. There is a high geographic concentration of memory chip design in South Korea (58%), with **Europe's position in the supply chain of memory chip design being completely negligible**.[102]
- **Equipment** can be categorised into different families, such as lithography equipment, deposition equipment, doping equipment, photoresist processing equipment, etc. Regarding market share, Europe's share is 18% compared to 41% for the USA and 36% for East Asia (Japan, Taiwan and South Korea). However, Europe's performance is noteworthy for EUV (Extreme Ultra-Violet) lithography equipment. For EUV equipment, a global network of specialised suppliers is needed, of which 32% come from the Netherlands and 14% from the rest of Europe,[103] compared to 27% from North America. Dutch ASML leads the market here.
- **Materials** supply is also highly specialised for semiconductors. The polysilicon used to make the wafers needs a higher purity level than solar energy panels. Europe has 12% a 12% share, China has a 13% share, and the rest of East Asia has a 57% share in the rials segment. For electronic-grade polysilicon, Europe performs better and occupies 50% of the market share with the USA. Speciality gas supply is also concentrated in Europe. But for photoresists, silicon wafers and packaging substrates, Japan and Taiwan have the geographic concentration. Other strengths of Europe include patterning (where ASML owns 90% of the market), metrology and inspection and wafer bonding.[104] It also has a strong presence in vacuum (particularly the vacuum pump market led by Edwards Vacuum), optical technological development (Zeiss provides optical systems used in photolithography), and notable expertise in the associated instrumentation and metrology.[105]

---

[102] https://www.semiconductors.org/wp-content/uploads/2022/11/SIA_State-of-Industry-Report_Nov-2022.pdf

[103] BCG & SIA Report uses the term EMEA excluding Netherlands but does not mention if any of them are based in Middle East or Africa.

[104] https://www.yolegroup.com/strategy-insights/underappreciated-eu-suppliers-lead-the-semiconductor-equipment-market/#:~:text=In%202023%2C%20European%20suppliers%20represented,total%20%2420%20billion%20subsystem%20market.

[105] *Ibidem*

- **Wafer fabrication** requires highly specialised manufacturing facilities or fabs. In global chip fabrication, the **European capacity share is below 10%**. The global economy relies on Taiwan for 92% of the production of 7nm and 5nm chips.[106] South Korea and Japan are the leading centres in memory chip fabrication. China also performs well for logic chips larger than 10nm.
- In **ATP**, assembly refers to converting silicon wafers produced by the fabs into finished chips ready to be assembled into electronic devices. Chips also need to be tested and packed in a protective frame. Europe again has virtually no presence at this stage, with almost all of the ATP happening in Asia, such as Taiwan, China, Malaysia, Singapore, Vietnam, and the Philippines.

Box 12: Selection of EU Clusters and sub-national strengths

Germany:

- Silicon Saxony includes Melexis, IMMS, X-Fab, Racytics, Photronics, Global Foundtries, Frauenhofer.
- The state of Bavaria is funding a preliminary project to pave the way for the Bavarian Chip Design Center BCDC just under EUR 1 million. Recipients are the Fraunhofer Institutes AISEC, EMFT and IIS. The project pools the chip design expertise of three Fraunhofer Institutes, Bavaria's SMEs and start-ups being the primary beneficiaries. The Center aims to provide easy access to highly developed generic circuit blocks, such as intellectual property cores or entire IP platforms like RISC-V.107 Bavaria also hosts other companies such as Apple, Texas Instruments, Bosch Group, Silicon Line, and Dialog Semi.
- The microTEC Südwest cluster in Baden-Württemberg is another cluster for intelligent microsystem technology solutions in production, mobility, health, and energy.
- On top of that, chip giants investing in Germany include: TSMC (Dresden), Wolfspeed (Ensdorf, Saarland), Intel (Magdeburg), Bosch, Globalfoundries, Infineon.

Finland:

- Finland is one of the countries that is actively developing its semiconductor industry. The electronics and photonics sectors currently employ around 5,000 people in Finland.[108] Finland has leading expertise across AD/DA converters, sensors, imaging chips, photon sources and detectors, lasers, RF and quantum chips, and thousands of other chips that are not processors or memories. Expertise also covers chip design. An example of leading expertise is in microelectromechanical systems MEMS, where the Finnish research and development has been a success story. Finnish Vaisala is one of the leading companies in the field. Besides companies, research institutes have a key role to play as enablers. These include Aalto University, University of Oulu, University of Tampere and VTT. 'Kvanttinova', a co-

[106] U.S. International Trade Commission. U.S. Exposure to the Taiwanese Semiconductor Industry. Economics working papers. 2023.
107 Frauhofer IIS (2022). Bavarian Chip Design Center – Boosting the region's innovative strength and economy. Available at: https://www.iis.fraunhofer.de/en/magazin/series/chipdesign_in_europe/vorprojekt-bayerisches-chip-design-center.html. Accessed: 16 April 2024. See also Frauhofer's role in the EUROPRACTICE project, which helps SMEs with manufacturing chips with small batch sizes: https://www.iis.fraunhofer.de/de/ff/sse/ic-design/virtual-asic-foundry.html.
108 Business Finland (2023). "Chips made in Europe" – Finland increases Europe's competitive advantage. Press release. Available: https://www.businessfinland.com/press-release/2023/chips-made-in-europe/. Accessed: 16 April 2024.

creation-based environment for piloting microelectronics and quantum technology, located in Otaniemi, Espoo.

- SIPFAB, a chip and system in a package (SiP) pilot environment to be situated in Hervanta, Tampere, would be a place to develop and test photonic chips.

France:

- Antibes (near Marseille) with companies Microchip, Maxim Integrated, Invia, StartChip, Macom, and ARM.
- Grenoble-Isère (MinaLogic) with companies such as Dolphin Design, Spintec, Minatec Enterprises, STMicroelectronics

Italy:

- Milano-Padova: Maxin Intergated, eSilicon, Micron, Infineon, Silicon Mitus, AMS, Allegro.
- Chips.IT Foundation, set up in the University of Pavia. Several private companies have expressed their intention to participate, through partnerships, in the Foundation's activities. The list includes Analog Devices, Infineon, Intel, Inventvm, NXP, PSMC, Sony and STMicroelectronics. Chips.IT will coordinate research and design activities to provide state-of-the-art equipment and software, and act as a centre of excellence to help train new generations of talent in the sector.[109]
- Catania-Sicily: Analog Devises, ST Microelectronics, NXP.

Austria:

- Three integrated device manufacturers (IDMs) are headquartered in Austria, with two local production facilities.[110] The enterprise employs up to 30,000 individuals in Austria and 46,000 globally. Including the relevant value chains of the ECSEL-Austria target group, the employment figure in microelectronics, embedded systems, and smart systems integration in Austria likely ranges between 65,000 and 85,000.
- SiliconAlps has established the "Area of Excellence Power Electronics" to support companies, research institutes, and start-ups in this field and bring them to the forefront. Industry in the Carinthia-Styria region. Electronics partners include CISC Semiconductor Infineon Technologies, NXP Semiconductors, Lam Research.
- SiliconAlps is part of the BRIDGESMEs - Boosting Resilience In five industrial ecosystems through adoption and Deployment of advanced technologies among SMEs. BRIDGESMEs aims to assist European SMEs in five industrial ecosystems (Mobility, Transport & Automotive; Aerospace & Defence; Electronics; Cultural & Creative Industries; Tourism) in re-thinking their business models and operations to become more resilient, sustainable, and human-centric.[111]

The Netherlands:

- ChipTech Twente and the Twente region are important EU sources for chip design. According to Innovation Origins, nine chip design companies in the region design (parts of) chips for various global manufacturers.[112]

109 " Italy sets up chips design centre in Pavia, attracts industry leaders". 7 November 2023. https://decode39.com/8185/italy-chips-design-centre-industry-leaders/.
110 See https://www.silicon-alps.at/about-us/region/.
111 See https://profile.clustercollaboration.eu/profile/cluster-partnership-initiative/3010c241-46c0-4a5e-a9ab-8714df914914.
112 Innovation Origins (2022). Twente aims to become the chip design center of Europe. Available at: https://innovationorigins.com/en/twente-aims-to-become-the-chip-design-center-of-europe/. Accessed: 16 April 2024.

- Large companies such as ASML and Philips have been establishing themselves in the Brainport region (the innovation ecosystem of Eindhoven) and they have smaller tech start-ups in the region.

Belgium:

- DSP Valley: ICsense, Imen, Nstilition, Caeleste, Melexis.

Others, which cut across microelectronics, ICT and digital are: ICT Cluster (Bulgaria)[113], National Portuguese ICT Cluster - TICE.PT[114], and Mobile Heights.[115]

A **majority of the estimated 10,000 companies in the semiconductor sector in Europe are SMEs, including start-ups**.[116] SMEs are part of the different stages of the supply chain and downstream as users. According to an interview with an industry association, there are three topics in semiconductors important to SMEs:

- Large companies such as ASML, ASM, NXP, and BE Semiconductors create a whole ecosystem of suppliers, often SMEs. SMEs can be independent suppliers to large firms or participate as a subsidiary within a larger group. There is no data on the portion of each group.
- SMEs are also involved in chip design, where they may develop a chip for a specific application (automotive, agriculture, biomedical, consumer electronics). Chips are relevant for many applications, and different clusters in Europe may specialise in different uses.
- SMEs are also original equipment manufacturers (OEMs) making the machines used to manufacture semiconductors.

Their position is assessed as most vulnerable in their role in chip design and as OEMs. Vis-a-vis chip design, SMEs are vulnerable since chips are designed for a specific application and when EU electronic production moves to the Far East, so does chip design. To address this, a possible solution is to set an ambitious target for domestic chip production of 20% by 2030 to stimulate design in the EU. This, in turn, will support the ambitious digital decade target of doubling the EU's global market share in semiconductors to 20%.[117]

According to some stakeholders, European companies innovate on a lesser scale and find it harder to access the investment needed to innovate than the semiconductor industry in North America and Asia. The SMEs are clustered in 4 regions (not counting the cluster in Wales, UK). These are Minalogic in Grenoble (France), Silicon Saxony in Dresden (Germany), DSP Valley in Leuven (Belgium) and High Tech NL in Eindhoven (Netherlands). SMEs and start-ups have a major presence in Minalogic, DSP Valley and High-Tech NL clusters.[118] Multiple factors explain the location decisions:

- For example, the Free State of Saxony – home to the Silicon Saxony cluster – enjoys a reputation as Europe's biggest micro- and nanoelectronics location. Companies located in the cluster benefit from knowledge transfer, intra-company synergies, and other positive externalities created due to close cooperation within the network.

113 See: http://www.ictcluster.bg/about-ict-cluster/
114 See: https://www.tice.pt/en
115 See: https://mobileheights.org/
116 Silicon Europe Alliance. Position Paper on the European Chips Act. 2022.
117 European Chips Act. Available at: https://digital-strategy.ec.europa.eu/en/policies/european-chips-act. Accessed: 16 April 2024.
118 https://csconnected.com/media/yq4bkzas/huggins-johnston-munday-xu-the-future-of-europe-s-semiconductor-industry-002.pdf

- In other cases, universities and research institutions provide the much-needed specialised labour pools which the industry requires, such as the Bavarian Chip Design Center BCDC and the Chips for Finland initiative, centred around the University of Twente.
- Government initiative and funding can also be important factors, such as the growth of Leuven, Belgium, a leading semiconductor research location.
- Finally, the concentration of what is defined as “tacit knowledge” amongst manufacturing and research institutions also defines clusters' location and is often an essential factor for further investments.

The Chips Act recognises their centrality. SMEs have been given special attention on two points: (i) more accessible access to finance and investment opportunities are needed; (ii) Competence centres will provide services to semiconductor start-ups and SMEs to improve design capabilities and develop skills.

4.1.1.2 Challenges and vulnerabilities

The global supply chain of semiconductors comprises more than 50 choke points, i.e., steps where one region holds more than 65% of the global market share.[119] This represents a high **risk of disruptions** due to natural disasters, accidents, infrastructure failures, cyberattacks and geopolitical tensions. The EU has acknowledged that the fragility of the semiconductor supply chain puts potentially every sector of the EU economy at risk of disruption, threatening, in particular, the EU's ability to reap the benefits of the digital transition and to ensure its digital sovereignty. One example is how the war in Ukraine affected the supply of semiconductor-grade neon (a key gas used in chip lithography). Around half the global supply of neon was provided by two Ukrainian firms, which had to shut down production in Mariupol and Odesa.[120]

While the EU has its strength in innovation, it can also double up as a vulnerability if the SMEs and start-ups driving the innovation get acquired by foreign firms. For example, two spin-offs, called M4S and Caliopa, from Belgium-based microelectronics research centre Imec were absorbed by Huawei in 2011 and 2013.[121] Accessing capital can be a problem for many start-ups and SMEs wanting to scale up. But even when they do attract investment, it may be foreign investment, and the foreign investors may shift the operation, IP and expertise overseas. Chip design SMEs face other challenges, such as bureaucratic hurdles in accessing EU funds and high IP license costs.[122]

The decline of wafer fabrication in Europe over the years, from 25% in 2000 to 8% in 2023, is also a significant vulnerability.[123] The scale of investment required to make a difference here means that large firms such as TSMC, Infineon and Intel will be the key players involved rather than SMEs. However, the SMEs might still play a supporting role as part of the fab ecosystem, but their potential role has received little attention in discussions about chip manufacturing. It should be noted that while Taiwan leads the world in wafer fabrication when it comes to trailing-

[119] European Parliamentary Research Service. The EU chips act: Securing Europe's supply of semiconductors. Briefing. 2022.
[120] European Parliamentary Research Service. The EU chips act: Securing Europe's supply of semiconductors. Briefing. 2022.
[121] https://www.politico.eu/article/belgium-chips-imec-rd-leader-rolls-back-china-ties/.
122 https://merics.org/sites/default/files/2021-12/MERICS%20SNV%20China%27s%20rise%20in%20semiconductors%20and%20Europe.pdf

[123] https://optima-da.com/the-big-six-and-europes-place-in-the-global-value-chain-of-semiconductor-production/.

edge wafer production (process nodes at 10nm and above), even China is outperforming Europe with companies like SMIC and Huahong.[124]

The ATP is another stage where the European presence is negligible because the process is labour-intensive, and most of it was outsourced to East or South Asia countries. However, technological innovation in advanced packaging can play a role in improving energy efficiency and increasing chip hip performance.[125] The EU research centres, for instance, Imec, CEA-Leti and Fraunhofer, have expertise in advanced packaging, but the EU lacks the capacity to benefit from it.[126]

4.1.2 OSA goals and overview of relevant policy initiatives

The European Chips Act[127] is an example of an initiative to improve Europe's strategic autonomy on various technologies. It is grounded in the assessment that Europe relies on companies from Asia for advanced chip fabrication and from the US for general design tools. It also puts in place measures to create an attractive investment environment and to reinforce Europe's technological leadership along the value chain. The EU also engages with partners such as the USA, Japan, Singapore, and Korea. Interviews suggested that the Chips Act is an important initiative which does not address the issues quickly enough.[128] The instruments introduced by the Act are listed in what follows:

- **The first pillar of the European Chips Act is the one directly targeted to and affecting SMEs.** It aims to strengthen the EU's position in the semiconductor pre-production phase and revolves around the "EU Chips Joint Undertaking," comprising 25 EU MS, Israel, Turkey, Norway, the European Commission, and hundreds of companies and research centres. As a result of actions in pillar 1, "SMEs and start-ups will have easier and faster access to foundry services via a single point of contact, and lower development costs due to support in design and system integration and the use of cost-efficient options [...]."[129]
- The Act also foresees actions to strengthen the industrial ecosystem by **networking competence centres** that offer semiconductor expertise and skills development across Europe. One industry association identified this as one of the critical benefits to SMEs since it will provide insights into what products are built in which EU economies.
- The Chips fund has a dedicated **semiconductor equity investment facility** under InvestEU to support scale-ups and SMEs to ease their market expansion.[130]

---

[124] https://www.stiftung-nv.de/sites/default/files/chinas_semiconductor_ecosystem.pdf.

[125] https://merics.org/sites/default/files/2021-12/MERICS%20SNV%20China%27s%20rise%20in%20semiconductors%20and%20Europe.pdf

[126]https://merics.org/sites/default/files/2021-12/MERICS%20SNV%20China%27s%20rise%20in%20semiconductors%20and%20Europe.pdf

[127] On 21 September 2023, the European Chips Act entered into force. PRESS RELEASE. 21 September 2023. Digital sovereignty: European Chips Act enters into force today. Brussels. Available at: https://ec.europa.eu/commission/presscorner/detail/en/ip_23_4518. EUROPEAN COMMISSION. COMMISSION STAFF WORKING DOCUMENT. A Chips Act for Europe. Brussels, 11.5.2022 SWD(2022) 147 final PART 1/4.

[128] Most measures address the problem that SMEs and start-ups have difficulty attracting the necessary investment to develop their ideas and scale. As the Chips Act states: "This has led to stagnating growth of an indigenous European ecosystem and ultimately 59 creating gaps at the cutting-edge of technology. Specifically, the EU's footprint in the fast-growing fabless design segment has declined to less than 1%". (Source: European Chips Act, pp.58-59)

[129] SWD Chips Act, p.73.

[130] The second pillar enables setting up vertically integrated production facilities and what are called "Open EU Foundries," which are fabs that produce chips designed by others for third parties. Companies can access state aid and direct EU-funding and

In addition to the Chips Act, the Industrial Alliance on Processors and Semiconductor technologies, set up in July 2021, is another measure to address strategic dependencies in semiconductors. It aims to identify current gaps in the production of microchips and the technology developments needed for actors of the electronics value chain, including academia, research, technology organisations, and users, to thrive, regardless of their size. On top of that, a new **Important Project of Common European Interest (IPCEI)[131] on Microelectronics and Communication Technologies** was approved in June 2023 involving 14 Member States, with 56 companies, including SMEs and start-ups, undertaking 68 projects. The Member States will provide up to EUR 8.1 billion in public funding, expected to unlock an additional EUR 13.7 billion in private investments.[132]

Other important categories of measures for the European OSA include:

- public-private partnerships for research, development and innovation, such as the European Centre for Science, Ethics and Law (ECSEL) (up to EUR 1.2 billion EU funding) and the Key Digital Technologies JU (up to EUR 1.8 billion EU funding);
- The European Innovation Council (EIC)'s Accelerator, a funding programme under Horizon Europe that offers support to start-ups and SMEs[133] and includes grant funding, direct investment, EIC Accelerator Challenge, EIC Accelerator Open, tailor-made Business Acceleration Services (BAS), and Streamlined application process;[134]
- The EU-US Trade and Technology Council has led to cooperation through the operationalisation of a joint early warning mechanism for disruptions in semiconductor supply chains and through the exchange of information and market intelligence to address the impact of non-market economic policies.[135]

Relevant examples of policies for semiconductors outside the EU are discussed below. Several key economies (including China and the USA) aim to increasingly source semiconductors from close allies or onshore parts of the semiconductor value chain, aiming to achieve "strategic autonomy" like the EU.[136]

In the USA, the US Chips and Science Act provides incentives for semiconductor manufacturing. It provides USD 52.7 billion for American semiconductor research, development, manufacturing, and workforce development, including (i) USD 39 billion in manufacturing incentives, including USD 2 billion for the legacy chips used in automobiles and defence systems, (ii) USD 13.2 billion in R&D and workforce development, and (iii) USD 500

national funding amounting for new fab construction; this second pillar is more targeted towards established semiconductors producers and financial support to them. The third pillar aims to ensure continuity of supply in case of a semiconductor crisis through a monitoring early warning indicators for shortages in chip supply relative to demand and escalation mechanisms to activate a semiconductor crisis stage

131 An IPCEI is a State aid tool for Member States allowing public co-financing under the condition that it concerns large integrated cross-border projects to overcome market failures and enable breakthrough innovation in key sectors and technologies, up to first industrial deployment, as well as important infrastructure investments, with positive spill-over effects for the EU economy at large. IPCEIs in Microelectronics: https://competition-policy.ec.europa.eu/state-aid/ipcei/approved-ipceis/microelectronics-value-chain_en

132 PRESS RELEASE. State aid: Commission approves up to €8.1 billion of public support by fourteen Member States for an Important Project of Common European Interest in microelectronics and communication technologies. 8 June 2023 Brussels. Available at: https://ec.europa.eu/commission/presscorner/detail/en/IP_23_3087.

133 Applicants from EU Member States and countries associated to the Horizon Europe programme: Single start-up or SME (including spin-outs); Small mid-caps (fewer than 499 employees) in need of rapid scale up of the TRL 9 activity. Mid-caps can apply for investment only. Natural persons or legal entities willing to set up an SMEs or a mid-cap.

134 EIC Accelerator, see: https://eic.ec.europa.eu/eic-funding-opportunities/eic-accelerator_en

135 https://www.whitehouse.gov/briefing-room/statements-releases/2023/05/31/fact-sheet-u-s-eu-trade-and-technology-council-deepens-transatlantic-ties/.

136 Haramboure, A., et al. 2023. "Vulnerabilities in the semiconductor supply chain", OECD Science, Technology and Industry Working Papers, No. 2023/05, OECD Publishing, Paris. Available at: https://doi.org/10.1787/6bed616f-en. Accessed: 10 April 2024, p.9.

million to provide for international information communications technology security and semiconductor supply chain activities. It also provides a 25 per cent investment tax credit for capital expenses for manufacturing semiconductors and related equipment. [137] The bill requires recipients to "demonstrate significant worker and community investments, including opportunities for small businesses and disadvantaged communities, ensuring semiconductor incentives support equitable economic growth and development". [138] Companies that receive subsidies cannot increase production of chips more advanced than 28 nm in "countries of concern" such as China and Russia, for the next ten years. This affects companies like Intel and TSMC. In general, the President's Council of Advisors on Science and Technology (PCAST) recommended the following measures to boost the semiconductor industry: "forming a national microelectronics training network for semiconductor workforce development across academic institutions, including minority-serving institutions and community colleges; fostering innovation by reducing the barriers of entry to startups; recommending the development of a "chipset platform" to enable startups and researchers to innovate at lower cost more rapidly; and setting a national semiconductor research agenda with fundamental research and grand challenges [...]". [139]

One good practice from the USA was identified in how businesses, universities, and the government collaborate to bring semiconductor production to Phoenix, Arizona. The benefits of the approach are a clear five-year plan agreed upon with factories and universities and ease of doing business, such as clear applications and fewer procedural requirements. These procedural requirements usually introduce a high regulatory burden to SMEs, and the US template suggests ways to simplify them.[140]

US President Biden proposed the Chip 4 alliance of the United States, Taiwan, Japan and South Korea in March 2022. The purpose was to combine the US's excellence in chip design with the manufacturing capabilities of the three Asian countries to ensure coverage of the entire supply chain. While still in the proposal phase, the parties have started engaging. Analysts point out that cooperation remains challenging due to the goal of reshoring supply chains away from China, tense cross-strait relations, and the difficulty of cooperation when national security is at stake.

South Korea is one of the largest providers of government incentives in semiconductor manufacturing, covering between 25% to 30% of total semiconductor manufacturing costs in 2022.[141] Today, South Korea contributes 20% of the global market share in revenue of advanced chips below 7 nm.[142] South Korea dominates the memory chip market, with domestic firms Samsung Electronics Co. and SK Hynix Incorporated holding close to 70% of the global market share.[143] South Korea's "K-Chips Act", passed on March 30, 2023, would increase the tax credit to 15% from the current 8% for large corporations investing in manufacturing facilities for semiconductors and other strategic industries.[144] SMEs would see

---

137. The White House, 2022. FACT SHEET: CHIPS and Science Act Will Lower Costs, Create Jobs, Strengthen Supply Chains, and Counter China. Briefing 9 August 2022. Available at: https://www.whitehouse.gov/briefing-room/statements-releases/2022/08/09/fact-sheet-chips-and-science-act-will-lower-costs-create-jobs-strengthen-supply-chains-and-counter-china/. Accessed: 10 April 2024.

138 *Ibidem*

139 *Ibidem*

140 *Ibidem*

141 Kim, Alex (2023). CHIP on the Shoulder. Available: https://www.wilsoncenter.org/blog-post/chip-shoulder. Accessed: 17 April 2024.

142 Henry Wai-chung Yeung, Shaopeng Huang, and Yuqing Xing (2022). From Fabless to Fabs Everywhere? Semiconductor Global Value Chains in Transition. Available: https://www.wto.org/english/res_e/booksp_e/07_gvc23_ch4_dev_report_e.pdf. Accessed: 17 April 2024.

143 Industrial Development Bureau, Ministry of Economic Affairs, R.O.C. (Taiwan), March 2023. Taiwan and the Global Semiconductor Supply Chain.

144 Stangarone, Troy (2023). "The Role of South Korea in the U.S. Semiconductor Supply Chain Strategy", part of the roundtable "The Role of Allies in the U.S. Strategy for Semiconductor Supply Chains," National Bureau of Asian Research (USA), April 13, 2023. Available: https://www.nbr.org/publication/the-role-of-south-korea-in-the-u-s-semiconductor-supply-chain-strategy/. Accessed: 17 April 2024.

the tax break go to 25%, up from the 16%. The measure is expected to boost domestic investment in the local chip industry, especially for Samsung and SK Hynix Inc, which are dominant producers of memory chips globally.

In 2022, Taiwan's wafer fabrication value was USD 90.7 billion, 63.8% of the global output value.[145] Taiwan is also dominant in IC design (20.1% global market share) and packaging and testing (58.6% global market share). TSMC is the global leader in chip manufacturing, and Taiwanese companies are present throughout the entire supply chain. Taiwan has been providing Taiwan-based semiconductor manufacturers with a high-quality investment environment, tax incentives, and R&D support, as well as setting up industrial parks, which have developed in some of the largest industrial clusters. More recently, in 2023, Taiwan raised tax breaks for local companies' R&D investment from 15% to 25%, and an additional 5% tax credit was offered for NT$ 10 billion (USD 0.3 billion) spent on new equipment for advanced process technology.[146]

4.1.3 Recommendations for future policy actions

SMEs in the semiconductor industry already benefit from a range of policy actions targeted at different levels and parts of the supply chain. Stakeholders suggested that:

- SMEs will benefit from a **clear strategic direction to plan and allocate resources**. One suggestion was for the EU to identify certain application areas for companies to focus on and particular focus per country, i.e. what is being produced in each Member State and how SMEs can serve the entire European market. This recommendation suggested combining a top-down and bottom-up approach to stimulate SMEs' role in the semiconductor supply chain. This would ensure that chip design and electronic production take place in Europe.
- This relates to the need for **strategic autonomy along the entire value chain**. Stakeholders pointed out that the EU should not look only at the production of semiconductor devices but also at the production of equipment used upstream in the value chain.
- Another suggestion was to ensure that SMEs are supported in business development by **creating connections between companies, especially in different countries**. This is something that local associations usually assist with and could be strengthened through the activities introduced in the Chips Act.
- Whilst funding in Europe is, in principle, available, SMEs find it **harder to identify the right funding opportunities** for them and fulfil application requirements.

145 Industrial Development Bureau, Ministry of Economic Affairs, R.O.C. (Taiwan), March 2023. Taiwan and the Global Semiconductor Supply Chain. Available at: https://www.roc-taiwan.org/uploads/sites/86/2023/08/20230824-TAIWAN-AND-THE-GLOBAL-SEMICONDUCTOR-SUPPLY-CHAIN.pdf. Accessed: 17 April 2024.

146 U.S. Department of State (2023). 2023 Investment Climate Statements: Taiwan. Available at: https://www.state.gov/reports/2023-investment-climate-statements/taiwan/. Accessed: 17 April 2024.

4.2 Telecommunications

Highlights:

- The telecommunication industry heavily relies on **semiconductors**. In 2017, telecommunication value chains in Europe accounted for merely 5% of the total, amounting to EUR 6.1 billion.[147] **Telecommunication electronic boards** are also essential products in the telecommunication industry, where the EU has less than a 5% share.
- **Europe's performance in telecom equipment manufacture has worsened in the last few years**, falling by half since 2010. While Asia's share has grown, the USA has managed to hold on to its share of world production. The EU is better in 'Line Telephone Equipment Production' (ahead of the USA and Japan) than in 'Radiocommunication Equipment Production' (behind the USA and Japan).[148]
- **Many telcos** (telecommunications service provider companies that transport information electronically) **have faced problems due to the disruption of supplies from OEMs and the rising price of telecom equipment**.[149] Ericsson, for example, pointed to supply chain problems that are responsible for the increase in costs and negative financial performance in 2022.[150]
- In the context of the SNS-JU, the 6G-IA has been active in trying to ensure a high SME participation since SMEs are recognised as the **catalyst for innovation**. SME's ability for "out of the box" thinking and their agility to rapidly develop and test ideas in multiple sectors, have been important assets in the industrial digitisation of the so-called vertical industries. SMEs in 5G and 6G are both technology providers, working with key ICT companies, as well as users of technology in order to develop application in new vertical sectors. In 6G, SME participation is ensured via the European digital innovation hubs and the working group of the European Technology Platform, which take the technology closer to the actual SMEs so they can take advantage of the solutions and monetize the technology.
- According to industry associations, challenges to SME involvement include complexity of the administrative procedures; difficulty to act as coordinator of projects; difficulty to identify where they should apply and how to apply across overlapping or complementary initiatives. They also benefit from clear strategic direction and action plans, in order to decide where to commit resources
- Stakeholders highlight that **foreign acquisition of SMEs and start-ups is a major problem**. It highlights that while the EU is good at innovation, it is falling behind the USA and Asia. Concerning IP, innovative technology, and know-how, Europe risks being siphoned off to foreign shores by non-European acquisitions.[151]

---

[147] European Commission, Directorate-General for Communications Networks, Content and Technology, Coulon, O., Olliver, J., Dubois, G. et al., Study on the electronics ecosystem – Overview, developments and Europe's position in the world – Final report, Publications Office, 2020, https://data.europa.eu/doi/10.2759/941678.

[148] https://op.europa.eu/en/publication-detail/-/publication/272a2468-489d-11ea-b81b-01aa75ed71a1/language-en

[149] https://www.telecomstechnews.com/news/2023/apr/26/85-of-telcos-projects-delayed-supply-chain-issues/

[150] https://media.txo.com/wp-content/uploads/2023/04/25230053/Navigating-the-supply-chain-chaos.pdf

[151] https://www.eangti.org/

4.2.1 Overview of the value chain, positioning of SMEs and strategic vulnerabilities

The telecom industry, especially the telecommunication infrastructure, is the "backbone of every economy"[152] and is interlinked with the ICT industry. It is also the most valuable industry in the electronics ecosystem, with EUR 405 billion in size, ahead of industrial (EUR 383 billion), data processing (EUR 379 billion) and automotive (EUR 306 billion) markets. This section will go through various parts of the telecommunication value chain and Europe's position in the industry before discussing the role of SMEs and major vulnerabilities in the industry.

4.2.1.1 Value Chain

The telecommunication industry consists of telecom equipment manufacturers, hardware and software suppliers, and service providers.[153] The decades of 1990s and 2000s saw liberalisation and privatisation of the telecom sector followed by consolidation.[154] The following points will go through some of the crucial phases, goods, services and technologies in the telecommunication sector:

- In 2016, **Europe's share in global telecommunication electronics production was a mere 3.5%**, landing it after China with a 51% share, the rest of Asia with 29%, and the USA with 6.3%[155] For the telecommunication sector, semiconductors are important inputs, and merely 5% of this segment was in Europe, amounting to EUR 6.1 billion. Telecommunication electronic boards are also an essential product in the telecommunication industry. Europe's share is dismal here, accounting for 4% of the value chain worth EUR 13 billion. Europe fares much better in telecommunication services (including fixed and mobile telephone services, Voice over Internet Protocol (VoIP), voice mail, call waiting, call forwarding, caller identification, three-way calling, etc.), where it accounts for 18% of the global value chain.[156]
- **In terms of telecommunications infrastructure suppliers, East Asian companies from China (such as Huawei and ZTE), Japan, South Korea, and American companies dominate.** The European companies Nokia and Ericsson are among the top five global corporations, especially in the carrier networks segment. In the telecoms software systems and services segment, American and Japanese companies (Cisco, Juniper Networks, and Fujitsu dominate, but the European Ericsson is also growing rapidly.[157]

---

[152] European Commission, Directorate-General for Communications Networks, Content and Technology, Coulon, O., Olliver, J., Dubois, G. et al., Study on the electronics ecosystem – Overview, developments and Europe's position in the world – Final report, Publications Office, 2020, https://data.europa.eu/doi/10.2759/941678.

[153] The European electronic communications code (Directive (EU) 2018/1972) defines 'electronic communications networks' as "means transmission systems, whether or not they are based on a permanent infrastructure or centralised administration capacity, and, where applicable, switching or routing equipment and other resources.

[154] https://academic.oup.com/book/10902/chapter/159152656; https://www.routledge.com/The-Privatisation-of-European-Telecommunications/From-Eliassen/p/book/9781138355927

[155] European Commission, Directorate-General for Communications Networks, Content and Technology, Coulon, O., Olliver, J., Dubois, G. et al., Study on the electronics ecosystem – Overview, developments and Europe's position in the world – Final report, Publications Office, 2020, https://data.europa.eu/doi/10.2759/941678.

[156] *Ibidem*

[157] Carriers are being helped by Network Functions Virtualizations (NFV), allowing virtualisation of physical networking infrastructure and platform resources such as storage, and Software Defined Networking (SDN), an approach to networking that uses software controllers to communicate with hardware infrastructure to direct network traffic, to lay the ground for 5G and IoT era. European Telecommunications Standards Institute (ETSI) NFV architectural model provides the framework for NFV to operate. See for details

- **5G, cloud and radio access network (RAN) are key technological developments in the telecom industry.** Some of the major trends in 5G network space are focus on Open RAN, 5G Standalone and 5G-Advanced, cloud solutions, and mobile network API exposure.[158] Cloud infrastructure and telecom service providers are experiencing a convergence with the rise of connectivity platform as a service (CPaaS), connectivity infrastructure as a service (CIaaS), and everything as a service (XaaS).[159]
- One of the current European Smart Networks and Services Joint Undertaking (SNS JU) aims to facilitate and develop industrial leadership in Europe in 5G and 6G networks and services. One of its core missions is to foster Europe's technology sovereignty in 6G by implementing the related research and innovation programme leading to the conception and standardisation around 2025. It encourages preparation for early market adoption of 6G technologies by the end of the decade. **In the context of the SNS-JU and the previous 5G research program 5G-PPP, the 6G-IA has been active in trying to ensure a high SME participation**.
- Telcos (a telecommunications service provider company that transports information electronically),[160] cablecos (or cable companies), tower companies, wireless telecom providers, network operators, virtualisation service providers, edge network operators and advanced telecom applications developers are some of the players operating in the telecommunication industry.[161] Original equipment manufacturers (OEMs) act as suppliers to the telcos.[162]

4.2.1.2 The role of SMEs

The majority of firms (97.2%) in the telecoms sector are small firms employing less than 50 employees, while 1.9% are medium-sized firms, and only 0.9% are large firms with more than 250 employees.[163] However, **the telecom sector has historically been dominated by major legacy telecom operators, namely, Orange, BT, and Deutsche Telekom, as well as** telecom infrastructure and network equipment suppliers such as Nokia and Ericsson.[164]

The advent of cloud and 4G, 5G and 6G networks and radio access network (RAN) is changing the market structure. The European Association of Next Generation Telecommunications Innovators (EANGTI) declared that telecom SMEs may be the key to building a more innovative, cost-effective and healthy telecom infrastructure in the future. [165]

---

https://www.juniper.net/gb/en/research-topics/what-is-network-functions-virtualization-nfv.html#:~:text=Network%20Functions%20Virtualization%20(NFV)%20is,compute%2C%20storage%2C%20and%20networking
https://www.ibm.com/topics/sdn
https://op.europa.eu/en/publication-detail/-/publication/272a2468-489d-11ea-b81b-01aa75ed71a1/language-en

[158] GSM Association (2023). The telecoms industry in 2023: trends to watch. Available at: https://data.gsmaintelligence.com/api-web/v2/research-file-download?id=74383877&file=040123-Trends-to-watch-2023.pdf. Accessed: 17 April 2024.

[159] Euractiv (2023). EU Commission mulls cloud providers regulation, update of fair share tax. Available at: https://www.euractiv.com/section/digital/news/eu-commission-mulls-cloud-providers-regulation-update-of-fair-share-tax/. Accessed: 17 April 2024. Kearney (2021). Transforming the telecom value chain—a platform business model. Available at: https://www.kearney.com/industry/telecommunications/article/-/insights/transforming-the-telecom-value-chain-a-platform-business-model. Accessed: 17 April 2024.

[160] https://www.sdxcentral.com/resources/glossary/telco/

[161] https://www.kearney.com/industry/telecommunications/article/-/insights/transforming-the-telecom-value-chain-a-platform-business-model; https://bscw.5g-ppp.eu/pub/bscw.cgi/d391067/2021-01_5G_SME_Brochure.pdf

[162] https://www.telecomstechnews.com/news/2023/apr/26/85-of-telcos-projects-delayed-supply-chain-issues/

[163] European Commission – DG Employment, Social Affairs and Inclusion. Comprehensive sectoral analysis of emerging competences and economic activities in the Electromechanical engineering industry in the European Union. Available at: https://applica.be/comprehensive-sectoral-analysis-of-emerging-competences-and-economic-activities-in-the-electromechanical-engineering-industry-in-the-european-union/. Accessed: 17 April 2024.

[164] See European Commission, Directorate-General for Communications Networks, Content and Technology (2020).

[165] https://www.eangti.org/

As software has become at the centre of the telecom industry, the EU has become home to several advanced SMEs. These SMEs are particularly well-placed to operate 4G and 5G networks and RAN, and provide core network functions, mobile core, and virtualised RAN.[166] SMEs are already present in notable numbers in 5G Infrastructure Public Private Partnership (5G PPP) and the following 6G SNS-JU, a joint initiative between the European Commission and European ICT industry.[167] In 2021, SMEs were 20.36% of participants in the 5G PPP and represented EUR 91.38 million in EU funding.[168] Since then, the participation of SMEs in the 5G PPP has reached 21.95% of EU funding, representing a total of EUR 156.3 million.[169] In 2021, 83 SMEs participated in 5G PPP projects, forming about 29% of the total 5G PPP participants.[170]

The SME Working Group (WG) is jointly supported by NetWorld2020 and the 5G IA.[171] In 2021, SME WG had more than 190 members, including 160 SMEs. About 350 SMEs are members of NetWorld2020, the European Technology Platform for telecommunications and related services and applications.[172] The new group of 6G-IA, fostering industrial leadership for Europe in 5G and 6G, has 63 SMEs as members.[173] 6G SNS-JU has a KPI of 20% SME participation. In a similar way to the previous 5G-PPP program, in Call 1, SMEs represent 18% of the total funding, while in Call 2 , 25% of the total funding was awarded to SMEs. Technological advancements are the key to changing the type of companies that operate in the telecom sector. Many start-ups have been at the forefront of developing and experimenting with new technologies in the telecom sector, and not just in 5G, RAN and 6G space.[174]

However, the growth rate seen by European SMEs is less than the counterparts in East Asia and the USA. Key vulnerabilities facing the telecom industry, including SMEs are:

- **Europe's performance in telecom equipment manufacture has worsened in the last few years, falling by half since 2010**. While Asia's share has grown, the USA has managed to hold on to its share of world production. In 2016, Europe made just 8% of the communications equipment, compared to China's share at 61% and the USA's share at 32%.[175] It does better in 'Line Telephone Equipment Production' (ahead of the USA and Japan) than in 'Radiocommunication Equipment Production' (behind the USA and Japan).[176]
- **Many telcos have faced problems due to the disruption of supplies from OEMs and the rising price of telecom equipment**.[177] Ericsson, for example, pointed to supply chain problems that are responsible for the increase in costs and negative financial performance in 2022.[178]
- EANGTI, has singled out the **foreign acquisition of the SMEs and start-ups as a major problem**. It highlights that while the EU is good at innovation, it is falling behind

166 See: https://www.eangti.org/.
167 https://5g-ppp.eu/
168 https://bscw.5g-ppp.eu/pub/bscw.cgi/d391067/2021-01_5G_SME_Brochure.pdf
169 https://www.networldeurope.eu/sme-wg/
170 https://bscw.5g-ppp.eu/pub/bscw.cgi/d391067/2021-01_5G_SME_Brochure.pdf.
171 https://bscw.5g-ppp.eu/pub/bscw.cgi/d391067/2021-01_5G_SME_Brochure.pdf
172 https://www.networldeurope.eu/sme-wg/
173 https://www.networldeurope.eu/sme-wg/
174 https://eustart-up.news/which-german-telecommunications-start-ups-are-influencing-europes-tech-landscape/
175 https://op.europa.eu/en/publication-detail/-/publication/272a2468-489d-11ea-b81b-01aa75ed71a1/language-en
176 https://op.europa.eu/en/publication-detail/-/publication/272a2468-489d-11ea-b81b-01aa75ed71a1/language-en
177 https://www.telecomstechnews.com/news/2023/apr/26/85-of-telcos-projects-delayed-supply-chain-issues/
178 https://media.txo.com/wp-content/uploads/2023/04/25230053/Navigating-the-supply-chain-chaos.pdf

the USA and Asia. Concerning IP, innovative technology and know-how, Europe risks being siphoned off to foreign shores by non-European acquisitions.[179]

4.2.2 OSA goals and overview of relevant policy initiatives

The telecommunication industry, particularly the 5G-related technologies, remains an essential pillar for the EU to achieve its OSA goals, especially to transition to a digital economy and for security. In Resilient EU2030, it is mentioned that "to increase the resilience of data transmission networks, the EU should build additional cable system capacities, address the rising concentration of submarine cable ownership, and ensure the successful deployment of 5G technology through public and private investment".[180] The Commission has also acknowledged the key role played by projects such as 5G cross-border corridors both in Europe's Digital Decade Strategy and in the Sustainable and Smart Mobility Strategy.[181]

The section below details the policies being pursued at the EU level which affect the telecom sector:

- **5G PPP Initiative:** The 5G Infrastructure Public Private Partnership (PPP) is a joint initiative between the Commission and the private ICT industry, including telecommunications operators, ICT manufacturers, service providers, SMEs, and research institutions. The 5G-PPP is now in its third phase, and many new projects were launched in 2018 (Box 13). The objective of the 5G PPP is to deliver solutions, architectures, technologies and standards for the ubiquitous next-generation communication infrastructures of the coming decade. The challenge for the 5G PPP initiative has been to secure Europe's leadership in the areas where Europe is strong or where there is potential for creating new markets such as intelligent transport, smart cities, e-health, education, media, etc. The overall aim is to support the European industry in successfully competing in global markets and opening new innovation opportunities.[182]

Box 13: 5G PPP Projects

The currently ongoing Research & Innovation (R&I) projects under the 5G PPP umbrella are part of the last two phases of the 5G PPP, namely Phase 3.5: 5G Core and CAM projects and Phase 3.6: 5G Innovations and Beyond 5G.[183] The projects under these two phases address the needs of four different R&I calls for proposals under the H2020 Work Programme, which are:

- H2020-ICT-41: 5G Innovations for Verticals with Third-Party Services
- H2020-ICT-42: 5G Core Technologies Innovation
- H2020-ICT-52: Smart Connectivity Beyond 5G
- H2020-ICT-53: 5G for Connected and Automated Mobility (Cross-Border)

---

179 https://www.eangti.org/
180 https://futuros.gob.es/sites/default/files/2023-09/RESILIENTEU2030.pdf.
181 https://digital-strategy.ec.europa.eu/en/policies/cross-border-corridors
182 https://5g-ppp.eu/
183 https://5g-ppp.eu/5g-ppp-reference-figure-2023/

Each of these R&I calls has specific targets regarding the technological areas for innovation and the expected impact of the research activities.[184]

- **The 6G Smart Networks and Services Joint Undertaking (SNS-JU)[185]** is being run by the 6G Smart Networks and Services Industry Association (6G-IA) [186] and the Commission. The 6G-IA has, according to stakeholders, 88 SME members.[187] The SNS JU enables the pooling of EU and industrial resources in Smart Networks and Services. It also fosters alignment with Member States for 6G Research and Innovation, and deployment of advanced 5G networks. The SNS JU sets out an ambitious mission and an EU budget of EUR 900 million for the period 2021-2027.188 In the context of the SNS-JU and the previous 5G research program 5G-PPP, the 6G-IA has been active in trying to ensure high SME participation.[189]

- **Support under Horizon Europe**[190]: One example of how Horizon Europe supports the telecom industry is provided by the 6GStart Project for the period May 2022 - Sept 2024, which, in turn, is a support action project to the 5G Infrastructure PPP.[191]

- **The Connecting Europe Facility (CEF)** is a key EU funding instrument that promotes growth, jobs, and competitiveness through targeted infrastructure investment at the European level. The Connecting Europe Facility (CEF Digital) digital part will support and catalyse public and private investments in digital connectivity infrastructures between 2021 and 2027. Out of the budget of EUR 28.4 billion, EUR 0.5 billion was marked for Telecom.[192] Together with other funding instruments, including the Recovery and Resilience Facility and the InvestEU, CEF Digital aims to support an unprecedented number of investments devoted to safe, secure, and sustainable high-performance infrastructure, particularly Gigabit and 5G networks across the EU. The main actions foreseen under CEF Digital include:[193]

    a. The first action is deploying very high-capacity networks, including 5G systems, in areas where socioeconomic drivers are located. Under the 5G connectivity for smart communities, the CEF2 Digital programme will grant funds for the rapid deployment and take up of 5G for smart communities and innovative applications. A dedicated Coordination and Support Action was also established is to create a set of good practice 5G use cases, which can be re-used as benchmarks for innovative applications also under other funding programmes across the Union.[194]
    b. The second action guarantees uninterrupted coverage with 5G systems of all major transport paths, including the trans-European transport networks. Under the 5G coverage along cross-border corridors, EU countries and industry are

[184] Each of these R&I calls has specific targets regarding the technological areas for innovation and the expected impact of the research activities. Within Phase 3.5: 5G Core and CAM projects, 5G Core Technologies Innovation has 8 projects and 5G-PPP 5G for Connected and Automated Mobility (CAM) has 3 projects, most of which began in September 2020 and ran for 3 years . Under Phase 3.6: 5G Innovations and Beyond 5G, the 5G innovations for Verticals with Third Party Services has 9 projects and 5G-PPP Smart Connectivity beyond 5G has 10 projects. See for details: https://5g-ppp.eu/5g-ppp-phase-3-5-projects/

[185] In November 2021, Council Regulation 2021/2085 established the SNS JU as a legal and funding entity as part of the 10 European Partnerships to step up the green and digital transition.

186 https://6g-ia.eu/

187 https://bscw.sns-ju.eu/pub/bscw.cgi/d111258/sme-brochure-02-2024.pdf

188 https://digital-strategy.ec.europa.eu/en/policies/smart-networks-and-services-joint-undertaking

189 https://bscw.sns-ju.eu/pub/bscw.cgi/d111258/sme-brochure-02-2024.pdf

190 Horizon Europe is an EU research and innovation programme and is the successor of the Horizon 2020 programme. It has a budget of EUR 95.5 billion and runs until 2027. https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en

191 https://5g-ppp.eu/projects/

192 https://eufundingoverview.be/funding/cef-connecting-europe-facility.

193 https://digital-strategy.ec.europa.eu/en/activities/cef-digital.

194 https://digital-strategy.ec.europa.eu/en/activities/5g-smart-communities.

cooperating to prepare the large-scale deployment of 5G corridors for Connected and Automated Mobility on European transport paths. The deployment of 5G cross-border corridors along transport paths throughout Europe is expected to contribute to the green and digital transformation of the EU economy and society. In particular, 5G-enabled Connected and Automated Mobility (CAM) is seen as a major enabler for improved road safety, optimised road traffic, reduced CO_2 emissions, and industrial competitiveness of both the transport and mobility sectors.[195]

c. The third action is deploying new or significant upgrades to existing backbone networks, including submarine cables, within and between Member States and between the Union and third countries. For this, the European Quantum Communication Infrastructure Initiative,[196] Backbone networks for pan-European cloud federations[197] and Backbone connectivity for Digital Global Gateway are relevant projects.[198]
d. The fourth action is implementing and supporting digital connectivity infrastructure related to cross-border projects in the areas of transport or energy, with projects such as Coordination and Support Action.

- **European Digital Innovation Hubs (EDIHs), were signalled as a good practice in the ways they make research and development accessible to SMEs**. European Digital Innovation Hubs (EDIHs) are one-stop shops supporting companies through: providing access to technical expertise and testing; providing innovation services, such as financing advice, training, and skills development; and helping companies tackle environmental issues, in particular the use of digital technologies for sustainability and circularity. EDIH are also being developed outside of Europe to promote EU technology
- **The European Parliament discussed a ban on Chinese telecom suppliers, and some MS have already enacted bans and restrictions** that mainly impact established players who dominate the equipment sector.[199]
- **Telecom regulations by the EU** were the first Telecom regulatory package adopted in 2002. It was later amended in 2009 and 2015. The European Electronic Communications Code (EECC), which entered into force in December 2018, modernises the European regulatory framework for electronic communications to enhance consumers' choices and rights, ensure higher standards of communication services, as well as boost investment for more connectivity and more digital innovation.[200] Table 5 shows the content of the current EU electronic communications framework.

Table 5. EU electronic communications framework

	Description
1	Directive 2002/58/EC (Directive on Privacy and Electronic Communications), as amended by Directive 2009/136/EC (Citizens' Rights Directive), which, inter alia, deals with the processing of personal data in the context of the provision of electronic communications services and contains provisions in relation to the security of networks and services and notification of breaches of security
2	Decision No. 676/2002/EC (Radio Spectrum Decision), which establishes the European policy for radio spectrum with the aim of ensuring coordination between EU member states and harmonisation conditions for the efficient use of radio spectrum
3	Regulation (EU) No. 717/2007 on roaming on public mobile telephone networks, as amended by Regulation (EC) No. 544/2009 and Regulation (EU) No. 531/2012

195 https://digital-strategy.ec.europa.eu/en/policies/cross-border-corridors.
196 https://digital-strategy.ec.europa.eu/en/policies/european-quantum-communication-infrastructure-euroqci.
197 https://digital-strategy.ec.europa.eu/en/activities/backbone-networks-pan-european-cloud-federations.
198 https://digital-strategy.ec.europa.eu/en/activities/backbone-connectivity.
199 https://www.europarl.europa.eu/RegData/etudes/ATAG/2019/637912/EPRS_ATA(2019)637912_EN.pdf.
200 https://ec.europa.eu/commission/presscorner/detail/en/ip_20_2482

	Description
4	Regulation (EU) 2015/2120, laying down measures concerning open internet access and amending Directive 2002/22/EC on universal service and users' rights relating to electronic communications networks and services and Regulation (EU) No. 531/2012 on roaming on public mobile communications networks within the European Union, amended by Regulation (EU) 2017/920
5	Directive 2014/61/EU on measures to reduce the cost of deploying high-speed electronic communications networks
6	Directive (EU) 2016/1148 concerning measures for a high common level of security of network and information systems across the Union (NIS Directive)
7	Regulation (EU) 2017/1953, amending Regulations (EU) No. 1316/2013 and Regulation (EU) No. 283/2014, regarding the promotion of internet connectivity in local communities (Wifi4EU).
8	Regulation (EU) 2018/1807 on a framework for the free flow of non-personal data in the European Union
9	Regulation (EU) 2018/1971 establishing the Body of European Regulators for Electronic Communications (BEREC) and the Agency for Support for BEREC (BEREC Office), amending Regulation (EU) 2015/2120 and repealing Regulation (EC) 1211/2009
10	The Directive (EU) 2018/1972 establishing the European Electronic Communications Code (the EECC Directive)
11	Implementing Regulation (EU) 2019/2243, establishing a template for the contract summary to be used by providers of publicly available electronic communications services pursuant to Directive (EU) 2018/1972

Source: https://www.lexology.com/library/detail.aspx?g=b1877b9d-a036-475e-a573-f1eb0211cd8a

4.2.3 Recommendations for future policy actions

Stakeholders in the telecommunications industry have voiced concern about foreign acquisition and siphoning off of European IP and tech to Asia and the USA. As a result, the key recommendations include strengthening the SME ecosystem through dedicated support and keeping innovation and IP in Europe to achieve digital sovereignty and competitiveness.[201]

In terms of foreign acquisition and IP, further tracking and analysis are required to understand the trends in the ecosystem. The EU's Foreign Direct Investment (FDI) Regulation, in place since October 2020, aims to ensure that the EU is better equipped to identify, assess and mitigate potential risks to security or public order while remaining among the world's most open investment areas.[202] The Regulation steps up information sharing and cooperation in the EU is necessary to identify new challenges and to react accordingly. By tracking FDI, Member States can more easily identify when foreign companies are investing in European telecom SMEs, start-ups, and large enterprises and flag that in the annual reporting.

Regarding the development potential of the ecosystem, the telecommunication industry calls for several action points:[203]

- **Co-creation,** including joint effort across industry players to develop a new generation of services and deployments for markets underserved by legacy operators. The effort should focus on advocating for cost-effective solutions for the next-generation networks (mobile core and RAN).
- **Public/private collaborations to develop eco-systems and use cases.** The 5G PPP is a good practice and its successor 6G SNS-JU, which can be explored further to adjust some problems and achieve their full potential. For instance, a review of the 5G PPP projects in 'Performance' field shows that the goals in this field were not fully achieved. The targets for "1000 times wireless area capacity, reduction of service creation time from 90 hours to 90 minutes, and dense deployments to connect 7 trillion devices" couldn't be achieved because they required a highly matured, globalised and economically resilient ecosystem of 5G deployments which is still years away. [204]

201 https://www.eangti.org/
202 See: https://policy.trade.ec.europa.eu/enforcement-and-protection/investment-screening_en
203 https://www.eangti.org/
204 https://5g-ppp.eu/wp-content/uploads/2023/11/5GPPP_in-review_2023.pdf

- **Dedicated EU funding to SME projects**. Funds can be channelled to build 10+ mobile 4G or 5G networks in Europe that are fully built and/or supplied by European SMEs, such as in rural areas or university campuses. Another way to direct funds to SMEs is to push for supplier diversification and require mobile network operators to spend a quota of their annual capital (capex) and operational (opex) expenditure on European SMEs.[205] 6G SNS-JU's SME KPI can be increased to 25% in line with recent participation results
- **Availability of spectrum**. Actions include enabling SMEs to build neutral host networks in areas where mobile network operators do not see any business case. This requires allowing mobile virtual network operators (MVNOs) to obtain access to all 4G/5G networks in Europe and enacting a regulatory framework in support of local spectrum licenses.
- **International cooperation** to promote EU standards and develop joint roadmpas are also a good practice e.g. EU-US TTC Roadmap of 6G and EDIH in Africa.

[205] For example, 5G PPP's public statements highlight that the initial KPI of at least 20% EC funding to go to SMEs in the 5G PPP. According to the understanding of the SME WG, the KPI of 20% was set in the 5G PPP because SMEs were representing about that share of economic value in the telecoms sector. However, stakeholders argue that since the SNS encompass not only the telecoms sector but also more IT-oriented sectors such as IoT, cloud, AI, where there are many SMEs, and the added value of SMEs in the ICT sector as a whole is between 40 and 75%, the actual economic value of SMEs in the broader SNS domain is assessed as 22 to 25%. This requires the adjustment of thresholds to require a higher portion to be allocated to SMEs.

5 OSA and SMEs in the digital ecosystem

Highlights:

- Cloud and edge computing, artificial intelligence (AI) and cybersecurity are all key enabling technologies for the digital transition. Both the adoption and the development of these technologies will be important to establish European digital sovereignty and render EU SMEs competitive on global markets. These technologies have cross-sectoral applications that make them strategic to several industries such as agriculture (e.g. precision farming), mobility (e.g. autonomous driving), retail (e.g. enterprise resource planning), aerospace and defence (e.g. drones software), and financial activities (e.g. fraud detection) to mention but a few.
- SMEs in cloud computing face significant competition from American giants (Amazon AWS, Microsoft Azure and Google Cloud Platform). These so-called hyperscalers can benefit from mature technology and infrastructure and hold over 70% of the market, compared with less than 15% for European cloud service providers. Due to the high costs of infrastructure, SMEs are mostly involved in the platform-as-a-service and software-as-a-services stages of cloud computing. There is more leeway in edge computing, which is still a nascent technology and for which hyperscalers do not yet have a dominant market share. In **AI**, there are at least 600 companies in the EU, with 60% being large or very large firms, while SMEs and mid-cap firms constitute the remaining 40%. European SMEs and mid-cap firms also constitute 25% of the total number of companies active in AI, only behind South Korea (34%), and 33% of them are registered as patenting companies, suggesting a somewhat vibrant ecosystem in R&D. Finally, 74% of EU cybersecurity firms (at least 17,000 in the EU) are micro- and SMEs, although they are more involved in system integration of cybersecurity software rather than its development. Indeed, fewer than 15% of the SMEs and mid-cap firms in the EU are registered as patenting companies in digital security, against 30% for very large firms.
- The main challenges EU SMEs active in these technologies face are: lock-in effects due to the market dominance of hyperscalers; lack of investment funding, both public and private (particularly in AI); fragmentation of the digital single market, which leads to larger non-EU companies to acquire the more innovative SMEs in the field (around 20-30% of the acquisitions of cybersecurity firms in 2023 were estimated to be from non-EU companies); and lack of skills due to the difficulty in retaining talent within the EU.
- European SMEs can also seize important opportunities to refine their competitive edge in the field. For instance, in cloud computing, SMEs can take advantage of the EU's push for open-source software and interoperability to develop multi-platform solutions and expand into specialised markets (e.g. space exploration). SMEs can also play an important role in edge technology thanks to the localised geographical structure and fill the gaps left by hyperscalers and telco giants. In AI, SMEs can play a bigger role in the solutions software market by providing niche solutions to investors and customers, thanks to the wide range of possibilities that general purpose AI allows for.
- The main EU-level measure in this field is the IPCEI-CIS for cloud and edge computing. Although led by larger companies, SMEs are involved both directly and as indirect partners. There is, therefore, large scope for spillovers in R&D in this area, which can particularly consolidate the position of European SMEs in edge computing. Other measures include the AI innovation package to support Artificial Intelligence

start-ups and SMEs of January 2024, which grants SMEs access to supercomputers for generative AI purposes, thanks to the Digital Europe Programme.

- Several EU Member States are also beginning to run many projects in this field as part of their National Recovery and Resilience Plans, which foresee around 20% of the expenditure for digital transformation. Nevertheless, many of these programmes aim to increase the uptake of key enabling technologies rather than develop them.
- Policy action to increase benefits and opportunities for SMEs should begin by addressing unfair software licencing practices and then move on to the widespread promotion of open-source software across the entire value chain and for different technologies. Decreasing administrative burdens, supporting access to financing and private investment (the latter particularly for AI), and promoting digital skills in a way that allows SMEs to retain talent will be critical steps to bolster the standing of European SMEs both in terms of adoption and development of key enabling technologies.

5.1 Overview of the value chain, positioning of SMEs and strategic vulnerabilities

This section addresses the issue of OSA in the digital ecosystem for three key enabling technologies: **artificial intelligence (AI)**, **cybersecurity** and **cloud and edge computing**. Such technologies – especially AI – were found to have a causal relationship with firms' growth and productivity.[206] With 99.8% of companies in the digital ecosystem being SMEs,[207] the ability to develop and adopt these technologies will be of paramount importance for the competitiveness of European SMEs and the strategic autonomy of the ecosystem.

These three technologies also present significant interlinkages: cloud computing is a necessity for the databases and data platforms which are needed for AI development; in turn, AI end-applications include systems to enhance the performance of edge computing and to improve cybersecurity; for their part, cybersecurity concerns involve all other technologies – as Commission President Ursula von der Leyen put it, 'if it's online, it can be hacked'.[208] Indeed, according to an interviewee, the EU is most dependent on cybersecurity technology in the cloud and edge domain. Moreover, SMEs can be directly or indirectly involved in cybersecurity attacks on supply chains, which may, in turn, have negative effects such as downtime of systems, monetary losses and reputational damages.[209] Indeed, according to the World Economic Forum's Global Cybersecurity Outlook 2024, 29% of organisations reported they had been materially affected by a cyber incident in the past 12 months.[210]

European SMEs face vulnerabilities when it comes to adopting and developing these technologies. If they fail to adopt these technologies, SMEs may grow less competitive against both large companies and non-EU firms. If they fail to join their development, the EU will become dependent on foreign digital service providers. It is therefore important to monitor

[206] EIB. (2024). *Investment report 2023-2024: Transforming for competitiveness*, p. 167.

[207] European Commission. (2023). *Monitoring the twin transition of industrial ecosystems: digital industrial ecosystem*.

[208] European Commission. (2021). EU chief announces cybersecurity law for connected devices. Available at: https://www.euractiv.com/section/cybersecurity/news/eu-chief-announces-cybersecurity-law-for-connected-devices/.

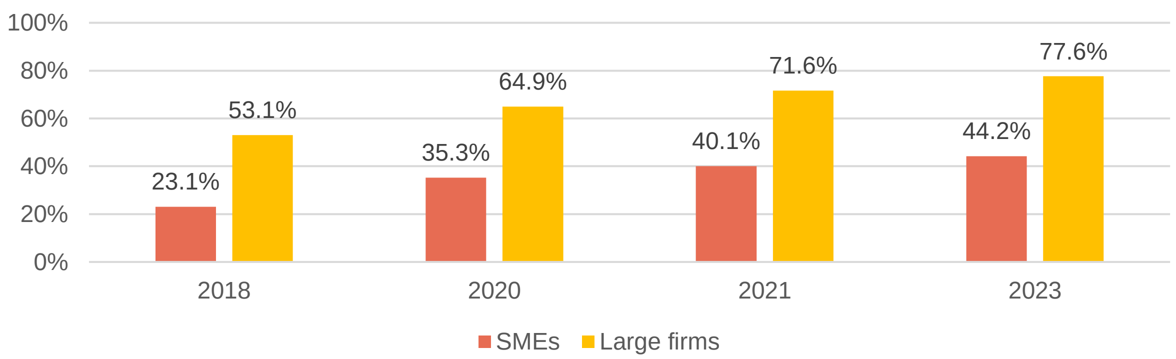
[209] ENISA. (2021). *Threat Landscape for Supply Chain Attacks*. Available at: https://www.enisa.europa.eu/publications/threat-landscape-for-supply-chain-attacks.

[210] WEF. (2024). *Global Cybersecurity Outlook 2024.* Available at: https://www.weforum.org/publications/global-cybersecurity-outlook-2024/.

both developments upstream, in terms of R&D&I, and downstream, in terms of digital uptake of businesses. In particular**, from the standpoint of OSA, a lower capacity to adopt innovative technologies can easily translate into reduced opportunities to develop new solutions based on these technologies**. For instance, as many digital services are now moving on to cloud-native technologies, heavier dependence on non-EU cloud service providers might hinder the capacity of European firms (especially SMEs, which lack the necessary infrastructure for cloud computing) to develop new innovative and alternative software solutions with cross-sectoral applications, thus impinging on the competitiveness of multiple ecosystems.

In terms of adoption, **the uptake of cloud computing among SMEs increased substantially during the pandemic** (see Figure 17), when companies needed to find new ways of doing business while in lockdown, with the share of SMEs using cloud computing increasing from 23.1% in 2018 to 35.3% in 2020.[211] However, **European SMEs still lag behind in cloud uptake compared to large firms**: while 44.2% of SMEs bought cloud computing services (of any kind) in 2023, 77.6% of large firms did.[212] Moreover, most companies only use the cloud for basic purposes such as e-mail (82.7%) and file storage (68%), while only 24.9% of SMEs bought cloud computing services of medium-high sophistication (vs 48.1% of large firms). Medium-high sophistication services include application development, testing or deployment (purchased by 26.1% of SMEs), enterprise resource planning software (25.9%), computing power to run the enterprise's own software (25.4%) or customer relationship management software (25.0%).[213] Nevertheless, EU companies appear to keep pace with their counterparts from other countries in terms of adoption of cloud computing, such as the US (44% in 2018), and the UK (59% in 2021), well ahead of the likes of Japan (21% in 2021) and Korea (28% in 2021).[214]

Figure 17. Uptake of cloud services among EU firms, by size, 2018, 2020-2021, 2023



Source: Authors' elaboration based on Eurostat table isoc_cicce_use.
Note: micro-firms (<10 employees) excluded.

[211] European Commission. (2023). *SMEs and high inflation*.
European Commission. (2023). Digital Decade DESI. 2023 – Cloud computing services uptake. Available at: https://digital-decade-desi.digital-strategy.ec.europa.eu/datasets/key-indicators/charts/analyse-one-indicator-and-compare-breakdowns?indicator=e_cc_ge_me&breakdownGroup=byentsize&period=2020&unit=pc_ent&country=EU

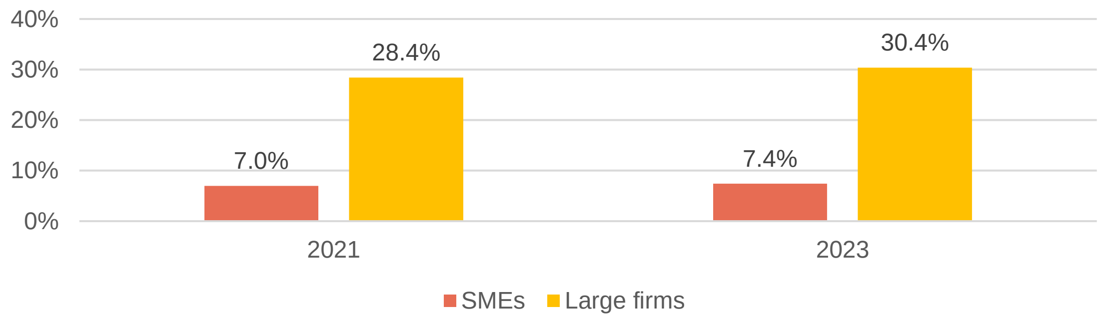
[212] European Commission. (2023). Digital Decade DESI. 2023 – Cloud computing services uptake. Available at: https://digital-decade-desi.digital-strategy.ec.europa.eu/datasets/key-indicators/charts/analyse-one-indicator-and-compare-breakdowns?indicator=e_cc_ge_me&breakdownGroup=byentsize&period=2020&unit=pc_ent&country=EU

[213] European Commission. (2023). Digital Decade DESI. 2023 – Cloud computing services uptake. Available at: https://digital-decade-desi.digital-strategy.ec.europa.eu/datasets/key-indicators/charts/analyse-one-indicator-and-compare-breakdowns?indicator=e_cc_ge_me&breakdownGroup=byentsize&period=2020&unit=pc_ent&country=EU
Eurostat. (2023). 45% EU enterprises bought cloud services in 2023. Available at: https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20231208-1.

[214] OECD. (2024). Share of businesses purchasing cloud services. Available at: https://goingdigital.oecd.org/en/indicator/25.

Adoption of AI technology among EU companies – especially SMEs – is even slower and may not reach the goal of 75% of EU firms employing some AI technology by 2030 set out by the Commission in the Digital Decade strategy. In 2023, only 7.4% of SMEs were using AI compared to 30.4% of large enterprises (Figure 18).[215] This represents a mere 5.7% increase for SMEs and 7% for large enterprises compared to 2021, suggesting a slow uptake. At this rate, only 20% of all firms will be using AI technologies by 2030.[216]

Figure 18. Uptake of AI among EU firms, by size, 2021, 2023



Source: Authors' elaboration based on Eurostat table isoc_eb_ai.
Note: micro-firms (<10 employees) excluded.

Finally, **the adoption of cybersecurity measures is more widespread among EU companies**, with 92% of companies with 10 or more employees using at least one ICT security measure. However, in 2022, only 37% of EU enterprises (ranging from 66% in Sweden to 18% in Greece) reported having documents on measures, practices or procedures on ICT security, which are necessary to keep the security measures up to date against the fast-evolving cyber threats.[217]

In terms of technology development, EU companies face even more important challenges. **In cloud computing, European companies are growing at a slower rate than non-EU cloud service providers, resulting in a decreasing market share.** At the end of 2022, 72% of the EU market share for cloud computing was in the hands of US companies (namely Amazon AWS, Microsoft Azure and Google Cloud Platform – the so-called hyperscalers) compared to just 13% for their European counterparts.[218] Such a dominant market position was achieved thanks to a combination of early market entry (already mid-2000s for AWS) and, therefore, first-mover advantage, but also massive infrastructure investment, which could be financed by leveraging their parent companies' portfolio of other mature products and operations.[219]

Hyperscalers benefit from strong vertical integration, which allows them to provide multiple services such as storage, databases, monitoring, networking, automation and security, whereas EU providers tend to focus on more specific subsets of cloud services.[220] Vertical integration also translates to little interoperability across platforms and services. As a result, European alternatives are not appetible to end-users. Aside from a few exceptions, EU

[215] Eurostat (2024). Artificial intelligence by size class of enterprise. Available at: https://ec.europa.eu/eurostat/databrowser/view/ISOC_EB_AI__custom_10112100/default/table?lang=en.

[216] Bianchini, N. & Ancona, L. (2023). Artificial intelligence: Europe needs to start dreaming again. Available at: https://www.robert-schuman.eu/en/european-issues/728-artificial-intelligence-europe-needs-to-start-dreaming-again.

[217] Eurostat. (2022). ICT security measures used by EU enterprises in 2022. Available at: https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20221208-2.

[218] Synergy Research Group. (2022). European Cloud Providers Continue to Grow but Still Lose Market Share. Available at: https://www.srgresearch.com/articles/european-cloud-providers-continue-to-grow-but-still-lose-market-share.

[219] Jarc, R. (2023). AWS, Azure, GCP. What makes them different in the eyes of customers? – research. Available at: https://www.uncoveralpha.com/p/aws-azure-gcp-what-makes-them-different.

[220] Clingendael. (2024). *Too late to act? Europe's quest for cloud sovereignty.* Available at: https://www.clingendael.org/sites/default/files/2024-02/Policy_brief_Cloud_sovereignty.pdf.

companies can at best, serve customers with specific local needs, sometimes working as partners to the big US cloud providers.[221]

Indeed, according to an interviewee, **many SMEs offer private or managed cloud services using the infrastructure of hyperscalers**, which usually results in a mutually beneficial partnership. However, **when it comes to large vertically integrated providers, EU SMEs are forced to cooperate with them**, as many of their customers demand 'must-have' software from these providers, which puts the hyperscalers in a dominant position in this relationship and employ unfair software licensing practices.[222] For instance, many European cloud infrastructure providers are re-selling Microsoft services at a loss of millions of euros a year since Microsoft is able to charge a 28% premium on the software licence where the customer wants to use it on a third-party cloud, such as the IaaS offering of an EU SME.[223]

According to a survey, this situation has created security concerns due to the non-EU proprietary hardware, resulting in 42% of business leaders being very or extremely concerned about critical data managed by US cloud providers (see also Box 14).[224] As such, according to an interviewee, **some European cloud service providers are starting to offer an alternative to hyperscalers, by providing in-house data centres for storage**, thus guaranteeing that the services are run on EU infrastructure. Some of them have managed to grow into mid-cap firms, such as Austria-based Anexia, founded in 2006 and which today counts 400 employees.[225]

Box 14: The 2018 US Cloud Act and its repercussions on EU companies, with an example from the automotive ecosystem

In 2018, the US Congress passed the **Clarifying Lawful Overseas Use of Data Act (CLOUD Act), which would allow the US government to enter into executive agreements with third countries for reciprocal expedited access to e-evidence held by providers based abroad**. In other words, the Cloud Act may remove domestic law restrictions so that service providers based in one of the countries party to the agreement can comply with direct orders for disclosure of electronic data issued by the other country. The Cloud Act executive agreements may, depending on the agreement of the parties, cover access to stored content and non-content data (any record or other information pertaining to a customer or subscriber of a provider) as well as real time interception of communications.

The Cloud Act is of relevance to the EU's quest towards digital sovereignty in two ways. First, because of its possible conflicts with EU Law involving the GDPR,[226] the Data Governance Act[227] and the Data Act.[228] Secondly, the EU wants to benefit from the data it creates, and allow European companies to grow thanks to larger data availability.

An example of how limited access to data can hamper the growth of EU companies is seen in the **automotive ecosystem**. **If the data of the vehicle is solely owned by the OEM** (which may not be a EU company, such as Tesla), **product development will become increasingly**

[221] European Commission. (2021). *Commission Staff Working Document – Strategic dependencies and capacities – SWD(2021) 352 final.*

[222] See: https://www.fairsoftwarestudy.com/.

[223] See: https://cispe.cloud/the-billion-euro-unfair-software-licence-tax-on-eu-customers/.

[224] CIO. (2023). DORA and its impact on data sovereignty. Available at: https://www.cio.com/article/652310/dora-and-its-impact-on-data-sovereignty.html.

[225] See: https://anexia.com/en/company/about-anexia/management.

[226] European Commission. (2016). *Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on he protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation).* Available at: https://eur-lex.europa.eu/eli/reg/2016/679/oj.

[227] European Commission. (2024). *European Data Governance Act.* Available at: https://digital-strategy.ec.europa.eu/en/policies/data-governance-act.

[228] European Commission. (2024). *Data Act*. Available at: https://digital-strategy.ec.europa.eu/en/policies/data-act.

more difficult. This will also have repercussions on the aftermarket, limiting the involvement of independent companies and shifting repairs and maintenance to authorised channels, which may be directly controlled by OEMs or have exclusive relationships with them.

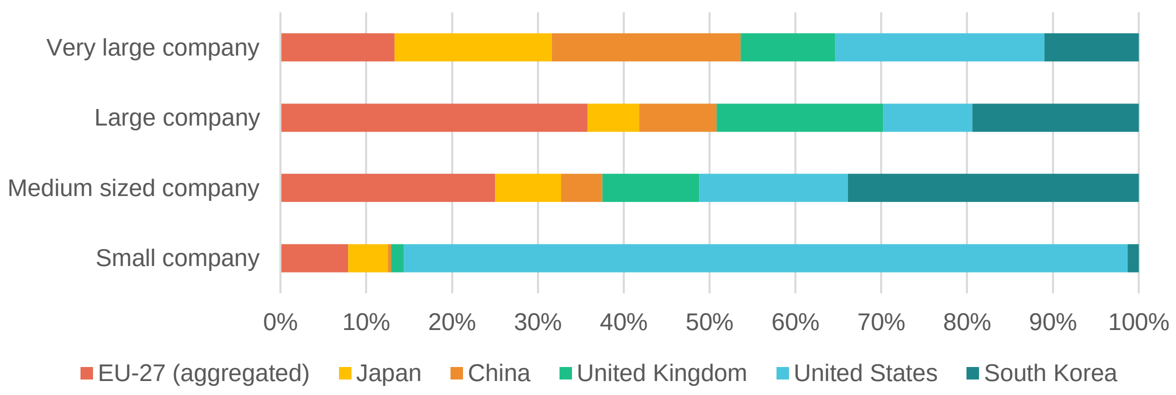
Hence, while the Data Act gives consumers control over data, this data does not create any significant market value because consumers do not have any ability to scale. At the same time, by limiting access to data to the OEM only, OEMs will act as gatekeepers, cutting out R&D centres and SMEs from development since the vehicle data will increasingly shape how car products are designed. As such, it will be difficult for SMEs and even mid-cap firms to have an independent role. On the contrary, such limitations empower OEMs (which are usually very large firms) and cut out innovation in the sector. Combined with the Cloud Act, this may create further hindrances to the global competitiveness of EU SMEs and mid-caps.

Source: Authors' elaboration based on Eurojust,[229] CSIS[230] and interviews.

There also are important vulnerabilities for EU AI firms upstream involved in R&D. According to the AI Watch database of the JRC, between 2009 and 2020, EU AI firms represented 16.5% of all AI firms among the major players (EU, US, UK, China, South Korea and Japan), but accounted for a mere 3.4% of total AI patent applications – far behind the US (18.4%) and China (67.8%).[231]

European SMEs and mid-caps active in AI, however, fare well when compared to other non-EU companies of similar size in the US, UK, China, Japan and Korea, according to RDI data based on 5,202 firms, 645 of which are based in the EU-27.[232] Among these countries, medium-sized European companies (defined as those having between 15 and 149 employees, according to the Orbis classification) constitute 25% of the total number of companies active in AI, only behind South Korea (34%), while large companies (between 150 and 1,000 employees) represent 36% of the total (see Figure 19). Of the SMEs and mid-caps active in AI in the EU, around 33% are registered as patenting companies, suggesting a somewhat vibrant sector in terms of R&D potential. Overall, **EU AI firms are for the majority of large or very large companies** (60%), while SMEs and mid-cap firms account for the remaining 40%.

Figure 19. Share of companies active in AI in the EU and other selected countries by firm size, 2020



[229] EuroJust. (2022). The CLOUD Act. Available at: https://www.eurojust.europa.eu/sites/default/files/assets/the-cloud-act.pdf.

[230] CSIS. (2023). The CLOUD Act and Transatlantic Trust. Available at: https://www.csis.org/analysis/cloud-act-and-transatlantic-trust.

[231] Authors' calculations from https://web.jrc.ec.europa.eu/dashboard/AI_WATCH_LANDSCAPE/.

[232] Due to RDI filtering criteria, the total number of firms is likely to represent a lower bound estimate. Indeed, some recent work suggests an estimate, for 2024, of around 6,000 AI start-ups in the EU, 10.6% of which are involved in generative AI. See: https://ai.appliedai-institute.de/en/generative-ai-in-the-european-start-up-landscape-2024.

Source: authors' elaboration based on RDI data.[233]
Note: a 'very large company' has more than 1,000 employees, a 'large' company between 150 and 1,000, a 'medium-sized company' between 15 and 149, and a 'small company' fewer than 15. A company is 'active' in a technology if at least one of three conditions are satisfied: at least 5% of a company's total patent portfolio is in a given technology; the company has at least 100 patents in a given technology; if a company's predicted CPC codes from its website data match those of a given technology.

According to a recent survey by the AppliedAI Institute for Europe, **generative AI start-ups in the EU are mostly involved in downstream applications** (63%). According to an interviewee, these AI companies' main concern is identifying market niches and selling solutions to clients who may not trust the data generated by AI software. Fewer start-ups are working on the development of tools and infrastructure (42%), and even fewer on the development of foundational models (31%). This is not surprising given that the development of such large language models is strongly capital intensive, and requires access to high-performance computing power, which most SMEs and start-ups lack. Indeed, the same survey suggests that over half of the surveyed start-ups (52%) requested access to EuroHPC (the European network of supercomputers) and that "one of the main obstacles European generative AI start-ups face is obtaining sufficient compute power."[234]

Finally, in cybersecurity, the EU keeps pace with the US in terms of scientific research, with 3,410 publications between 2013 and 2023, against 4,275 for the US (China is third with 1,660).[235] This result is likely due to the long-standing interest that the Union has taken in computer security and electronic communication, which dates back to the early 1990s.[236] However, **the EU lags significantly behind when it comes to the development of new cybersecurity products and technologies**, with just 237 patents between 2013 and 2023, against 6,548 for China and 1,426 for the US (South Korea is third with 405)**.**[237] A reason for this may be **that three-quarters of EU cybersecurity companies are micro and SMEs (74%), which, however, tend to operate in just the last mile of the value chain, focusing on system integrators** putting together products from third parties, or even focusing on security incident response, according to an interviewee.[238] Indeed, according to RDI data, out of 17,756 firms active in digital security, fewer than 15% of SMEs and mid-caps in the EU are registered as patenting companies, against 30% of very large firms.[239] This is also bolstered by insights from an interview, which suggested that the lower number of patents in the European cybersecurity market might be due to the lack of big players: only 67 of the top 500 global cybersecurity firms are based in Europe (e.g. F-Secure in Finland or BitDefender in Romania).[240] However, the interviewee does not expect to see any particular geographical pattern of distribution for cybersecurity SMEs – if any, some cybersecurity SMEs may be more

---

[233] See https://rdimonitoring.technote.ai/. It should be noted that, while RDI data cover all the NACE sectors, it is not representative of the EU economy. RDI tends to over-represent manufacturing firms and under-represent services firms (correlation coefficient r = 0.4 for all non-financial activities in the business sector B-N). However, for NACE J more specifically, which represents a significant portion of the digital ecosystem, the correlation coefficient increases to r = 0.87 across all 2-digit codes.

[234] AppliedAI Institute for Europe. (2024). *Generative AI in the European Start-up Landscape 2024*. Available at: https://143127253.fs1.hubspotusercontent-eu1.net/hubfs/143127253/Generative%20AI%20Study/Study_Generative_AI_in_the_European_Start-up_Landscape.pdf?utm_medium=email&_hsmi=81639974&utm_content=81639974&utm_source=hs_automation.

[235] TIM Analytics. (2024). *Cybersecurity Publications.* Available at: https://www.timanalytics.eu/TimTechPublic/main.jsp?analyzer=timeseries$Time%20series_1$s_370&dataset=7338.

[236] Carrapico, H., & Barrinha, A. (2018). European Union cyber security as an emerging research and policy field. *European Politics and Society*, *19*(3), 299-303.

[237] TIM Analytics. (2024). *Cybersecurity Patents.* Available at: https://www.timanalytics.eu/TimTechPublic/main.jsp?analyzer=timeseries$Time%20series_1$s_370&dataset=7336.

[238] Commission 2022 EU strategic dependencies and capacities: second stage of in-depth reviews

[239] Due to RDI filtering criteria, the total number of firms is likely to represent a lower bound estimate. An earlier study on Cybersecurity Industry Market Analysis suggests that in 2016 there were at least 60,000 firms active in the cybersecurity domain, although this number also includes British firms. See: European Commission. (2019). *Cybersecurity Industry Market Analysis.* Available at: https://op.europa.eu/en/publication-detail/-/publication/0be963c5-ca06-11e9-992f-01aa75ed71a1.

[240] European Commission. (2019). *Cybersecurity Industry Market Analysis.* Available at: https://op.europa.eu/en/publication-detail/-/publication/0be963c5-ca06-11e9-992f-01aa75ed71a1.

likely to be concentrated where established bigger players are already present, such as France, which has an important tradition in the domain, with several major players in the sector, such as Capgemini, Atos, Orange Cyberdefense, and Airbus.

There are four main reasons behind the slow development and uptake of these technologies among EU firms, and especially among SMEs and start-ups.

- **Lock-in effects that hamper competition**. Lock-in effects in **cloud computing** have significant competition risks: it becomes harder for smaller providers and newcomers to compete, especially for such markets, characterised by strong economies of scale and scope.[241] Likewise, in **cybersecurity**, SMEs face challenges because users prefer less innovative but more consolidated solutions, providing international competitors with an important advantage in the European market. Hence, many European companies are finding it much more difficult to develop products in Europe.[242] An interviewee also mentions the difficulty in scale-up, according to whom major R&D investments may result in start-ups. However, obtaining investment for scale-up afterwards is more difficult, as the more successful companies are leaving the EU and being acquired by non-EU companies.
- **Lack of investment funding**. Lack of funding is a problem both at the public and private level due to cultural differences with other countries – while the European banking system is rather risk-averse and public authorities are mostly involved in 'de-risking', a strong risk-taking culture characterises the US investment market, and Asian markets benefit from considerable government-driven innovation funding programmes. Moreover, according to the 2023 European Deep Tech Report, VC funding in Europe (including the UK and Switzerland) comes almost entirely at the pre-seed stage, while the share of funding in the USA and Asia increases to nearly 50% at late-stage rounds. This lack of continuous support to start-ups puts Europe's independence in disrupting technologies from the USA and China at risk.[243] In **cybersecurity**, public EU spending comes from the general budget and the Member States' co-founding. Venture capital (VC) investment for cybersecurity in the EU amounted to just EUR 814 million in 2021 – rather underwhelming compared with EUR 15 billion in the US and EUR 2.5 billion in Israel. As a result, the financial gap in the EU for cybersecurity companies is in the range of EUR 1.3 ~ 2 billion per year, which an interviewee also confirmed.[244] A similar situation exists in the **AI** market: large institutional investors in the EU account for only 14% of the VC market, compared with 35% in the US. VC investment in AI in 2023 was seven times higher in the US (USD 55 billion) compared with the EU (USD 8 billion), and 25 times higher for generative AI (USD 600 million in the EU vs USD 16 billion in the US).[245] SMEs struggle to connect with investors, especially in the early stages when investment is more concentrated in local markets. According to an EIB survey, **30% of AI SMEs struggled to find the right investors, while 25% said they would benefit from initiatives that help match small firms and investors across the EU**.[246]

---

[241] Carugiati. C. (2023). The competitive relationship between cloud computing and generative AI. Available at: https://www.bruegel.org/sites/default/files/2023-12/WP%202023%2019%20Cloud%20111223.pdf.

[242] EIB. (2022). *European Cybersecurity Investment Platform*. Available at: https://www.eib.org/attachments/lucalli/20220206-european-cybersecurity-investment-platform-en.pdf.

[243] Lake Star, Walden Catalyst and dealroom.co. (2023). *The 2023 European Deep Tech Report*. Available at: https://dealroom.co/uploaded/2023/09/The-European-Deep-Tech-Report-2023.pdf.

[244] EIB. (2022). *European Cybersecurity Investment Platform*. Available at: https://www.eib.org/attachments/lucalli/20220206-european-cybersecurity-investment-platform-en.pdf.

[245] See: https://oecd.ai.

[246] EIB. (2021). *Artificial intelligence, blockchain and the future of Europe: How disruptive technologies create opportunities for a green and digital economy.* Available at: https://www.eib.org/attachments/thematic/artificial_intelligence_blockchain_and_the_future_of_europe_report_en.pdf.

- **Lack of a digital single market**. The main implication of the lack of a digital single market is the fragmentation of the EU value chains for these technologies, hampering EU SMEs' ability to scale up and compete globally. As a result, European companies cannot compete with their American counterparts when it comes to acquisitions and retaining talent.[247] On the contrary, there is a trend of European SMEs being acquired by American companies. In **cloud computing**, for instance, in 2019, US-based New Relic acquired the Belgian CoScale, a provider of monitoring for containers and micro-services, a key architectural approach for cloud computing.[248] A similar situation is present in the **AI** market, which is reflected in the lack of access to the data necessary to train the AI models: much of it is in the hands of non-EU big tech firms and is not inter-operable, thus reducing the incentives for data-driven businesses to emerge, grow and innovate within the European Union.[249] Developing and scaling European SMEs in cybersecurity is difficult, particularly in fields such as encryption, because of increasing M&A (mergers and acquisitions) activity from non-EU firms looking to acquire small innovative companies.[250] According to an interviewee, preliminary estimates suggest that between 20 and 25% of the acquisitions in 2023 involved non-EU companies as the acquirer.
- **Lack of digital skills**. The lack of digital skills is a cross-sectoral issue. In many cases, the problem for European companies is less about producing talent than retaining it.[251] Europe accounts for 18% of top-tier AI researchers (against 20% from the US and 29% from China) but employs only 10% of them (against 59% in the US).[252] The number of skilled and qualified cybersecurity workers is also insufficient to meet demand, with a workforce gap of around 348,000 people in Europe.[253] According to a cybersecurity-focused study by the EIB, 83% of surveyed SMEs cite the lack of a skilled workforce as a barrier to growth. European companies also suffer from fragmentation in research projects and activities, which is slowing down the creation of a strong cybersecurity value chain.[254]

Despite these vulnerabilities, European SMEs are playing an important role in several areas**.** For **cloud computing**, interviewees mentioned two cases in which SMEs play an important role. SMEs operating in **multi-cloud platform solutions** are helping address the lack of interoperability through the promotion of open-source software applications. Their ability to develop state-of-the-art cloud platforms allows them to penetrate the B2B market, offering other companies the opportunity to not be bound by a single cloud service provider. The European Commission is also playing a role in aiding these efforts through new legislation that

---

[247] Bianchini, N. & Ancona, L. (2023). Artificial intelligence: Europe needs to start dreaming again. Available at: https://www.robert-schuman.eu/en/european-issues/728-artificial-intelligence-europe-needs-to-start-dreaming-again.

[248] Lunden, I. (2018). New Relic acquires Belgium's CoScale to expand its monitoring of Kubernetes containers and microservices. Available at: https://techcrunch.com/2018/10/11/new-relic-acquires-belgiums-coscale-to-expand-its-monitoring-of-kubernetes-containers-and-microservices/.

[249] EIB. (2021). *Artificial intelligence, blockchain and the future of Europe: How disruptive technologies create opportunities for a green and digital economy.* Available at: https://www.eib.org/attachments/thematic/artificial_intelligence_blockchain_and_the_future_of_europe_report_en.pdf.

[250] EIB. (2022). *European Cybersecurity Investment Platform*. 2022. Available at: https://www.eib.org/attachments/lucalli/20220206-european-cybersecurity-investment-platform-en.pdf.

[251] Bianchini, N. & Ancona, L. (2023). Artificial intelligence: Europe needs to start dreaming again. 2023. Available at: https://www.robert-schuman.eu/en/european-issues/728-artificial-intelligence-europe-needs-to-start-dreaming-again.

[252] Macro Polo. (2024). The Global AI Talent Tracker 2.0. Available at: https://macropolo.org/digital-projects/the-global-ai-talent-tracker/.

[253] ISC2. (2023). *How the economy, skills gap and artificial intelligence are challenging the global cybersecurity workforce.* Available at: https://media.isc2.org/-/media/Project/ISC2/Main/Media/documents/research/ISC2_Cybersecurity_Workforce_Study_2023.pdf?rev=28b46de71ce24e6ab7705f6e3da8637e

[254] EIB. (2022). *European Cybersecurity Investment Platform*. 2022. Available at: https://www.eib.org/attachments/lucalli/20220206-european-cybersecurity-investment-platform-en.pdf.

provides a framework for customers to effectively switch between cloud service providers free of charge.[255] SMEs are also active in areas of **specialised cloud applications** and services, such as providing the necessary cloud platform support for companies and research centres involved in space exploration. For instance, Polish SME CloudFerro builds and operates cloud computing platforms for the European space sector. Activities include storing and processing big data sets, such as multipetabyte repositories of Earth Observation satellite data.[256]

Box 15: The importance of open-source software for SMEs: the case of VMware

The development of open-source software for interoperability is of pivotal importance to European SMEs, as the case of VMware can exemplify.

VMware provides a very extensive virtualisation stack that allows cloud service providers and enterprises to run a virtual computer on a physical computer, exploiting cloud engineering.

In 2023, US-based Broadcom acquired VMware for close to USD 70 billion.[257] However, the strategy pursued by Broadcom saw the imposition of increases in software licences up to 1300%, according to an interviewee, which was aimed at eliminating the less profitable customers. SMEs, especially, saw their licences rescinded and would only be able to continue to use VMware through a 'white label' solution offered by the larger cloud service providers. According to an interviewee, this labelling scheme would also force SMEs to partner with competitors, providind them with access to their own infrastructure and disclose sensitive customer data.

Such a strategy had a major impact on European cloud service providers that could not afford this increase in prices. This has pushed some SMEs to move onto open-source software that, had it been unavailable, would have most likely seen these SMEs cease their operations. However, according to an interviewee, switching providers is neither easy nor fast: in some cases, it could take more than a year to make the transition. Hence, the acquisition of VMware by Broadcom entails that European cloud service providers are locked in a very disadvantageous relationship with Broadcom.

This issue shows how vulnerable SMEs can be to the whims of large software providers.

Source: Authors' elaboration based on interviews.

An area in which EU SMEs could particularly thrive is edge computing. Since edge computing brings computation and data storage closer to the source, European SMEs can leverage the geographically localised nature of edge nodes. Such operations require less investment in infrastructure, while hyperscalers may not have the capillary reach necessary for data to travel across edge nodes. At the same time, edge computing requires the presence of a dense network of edge nodes, with the Commission aiming for 10,000 by 2030 (one node every 100km). Yet, as of 2023, only around 700 nodes are active, most of which are used for piloting projects.[258]

A further opportunity for European SMEs to overcome the dominance of cloud hyperscalers comes from cloud-native technologies (e.g. micro-services and containers) that are designed specifically for the cloud. These technologies can take full advantage of non-mature technologies such as edge computing, and several projects are being supported by the Cloud

[255] European Commission. (2024). Data Act. Available at: https://digital-strategy.ec.europa.eu/en/policies/data-act.

[256] See: https://cloudferro.com/.

[257] Reuters. (2023). Broadcom closes $69 billion VMware deal after China approval. Available at: https://www.reuters.com/markets/deals/broadcom-closes-69-bln-vmware-deal-after-china-approval-2023-11-22/.

[258] European Commission. (2023). *Edge Deployment Data Report Edge Observatory for Digital Decade - Edge Computing Nodes: Characterisation, Deployment Monitoring and Trajectories*.

Native Computing Foundation (CNFC) based in Paris.[259] SMEs and start-ups can, therefore, play a more relevant role in this area. According to the cloud SME association EUCLIDIA, despite the strong presence of hyperscalers in the EU market, European SMEs are already in a position to supply and operate a full edge cloud platform. More specifically, SMEs could provide virtualisation functions (i.e. software that imitates hardware for virtual machines), support management functions, IT automation services, and others.[260] Nevertheless, these operations hinge on the availability and widespread use of open-source software to avoid a market crowd-out for SMEs due to licencing.

European SMEs can also take advantage of the general purpose of AI by specialising in niche markets. AI can be used in fields such as robotics, healthcare, agrifood, and mobility, to highlight but a few. SMEs and start-ups are also most often involved in downstream applications of AI software. **According to an interviewee, opportunities may arise particularly for private investment, with venture capitalists looking to invest into start-ups to distribute AI solutions that can find a ready application in niche markets**. For instance, a consortium led by the German electronics company Bosch recently invested USD 500 million in the AI start-up Aleph Alpha to provide software solutions with explainable and trustworthy generative AI. An advantage of using German-based Aleph Alpha also directly relates to digital sovereignty issues: Aleph Alpha's solutions can be operated in Bosch's own data centres and run on Bosch's own hardware. This means greater security for confidential data compared to what is offered by non-EU cloud service providers.[261] However, private investment through venture capital in the EU is still not widespread due to the risk-averse nature of investors (see Box 16).

Box 16: Venture capital investment in AI: an international comparison

According to interviewees, **the growth of the AI ecosystem in Europe is stymied by the lack of a compatible venture capital (VC) approach as in the US**. Indeed, start-ups do not yet have sufficient access to the investment they need to be able to train their models and scale up their activities to become globally competitive.[262] Similarly, a report by the AppliedAI Institute for Europe notes that an important hurdle for start-ups is finding investors who understand the potential of generative AI. VC investors, in particular, appear to lack an understanding of the development costs required for generative AI, which leads investors to focus on companies with a proven track record and steady revenue growth instead.[263]

Data from the OECD also supports the lack of private financing in AI: **while in 2023 VC investment in AI start-ups amounted to almost USD 55 billion, in the EU the sum was short of USD 8 billion – even less than China, with over USD 18 billion.** In generative AI, the EU is slightly ahead of China, but far behind the US, with just two firms – OpenAI and Anthropic – collecting EUR 14 billion in funding as of December 2023.[264] VC investment in computing AI start-ups is also far lower in the EU, although this is redressed by the EuroHCP JU to allow SMEs and start-ups access to the European network of supercomputers. Finally,

[259] See: https://www.cncf.io/.

[260] See: https://www.euclidia.eu/background/.

[261] Bosch. (2023). *Bosch Ventures co-leads investment round in AI start-up Aleph Alpha.* Available at: https://www.bosch-presse.de/pressportal/de/en/bosch-ventures-co-leads-investment-round-in-ai-start-up-aleph-alpha-259968.html.

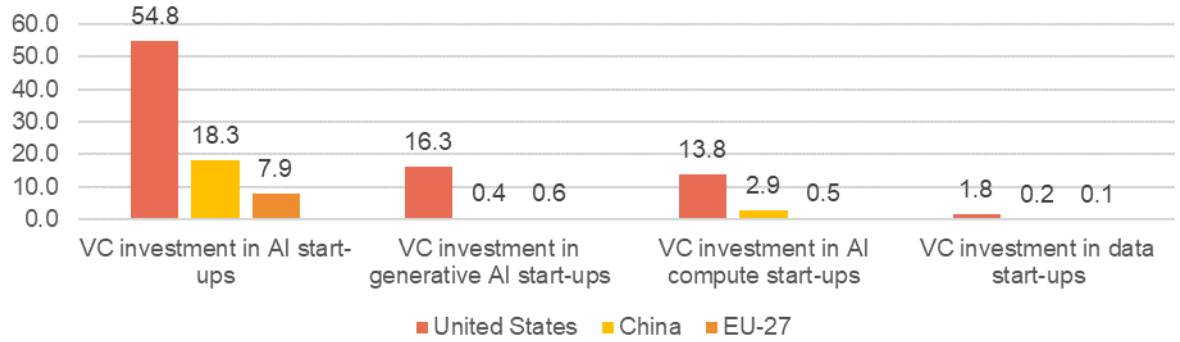
[262] European Commission. (2024). *COM(2024) 28 final – Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions on boosting start-ups and innovation in trustworthy artificial intelligence.*

[263] AppliedAI Institute for Europe. (2024). *Generative AI in the European Start-up Landscape 2024*. Available at: https://143127253.fs1.hubspotusercontent-eu1.net/hubfs/143127253/Generative%20AI%20Study/Study_Generative_AI_in_the_European_Start-up_Landscape.pdf?utm_medium=email&_hsmi=81639974&utm_content=81639974&utm_source=hs_automation.

[264] *Ibidem*

VC investment in data start-ups represents a far smaller share of total VC investment in AI in all three polities.

Figure 20. VC investment in AI-related activities in the EU-27, US and China (USD billion), 2023



Source: authors' elaboration from oecd.ai data.
Source: Authors' elaboration based on interviews, desk research and oecd.ai data.

Finally, an interviewee suggested that **a key opportunity for SMEs in cybersecurity is constituted by cybersecurity certifications**. When the larger players in the industry would like to certify something, they rely on specialised SMEs, who can certify certain products or tools through a national body assessment and national certification authority.[265] This kind of activity is particularly important in light of the centrality trust plays within the cybersecurity ecosystem, especially at the national level – a security system working in a country may not work as well in another country. Moreover, the interviewee mentioned the **possibility of SMEs supplying integrators to large space and defence companies** as a possible opportunity to contribute to the ecosystem (see Chapter 7).

5.2 OSA goals and overview of relevant policy initiatives

The main OSA-related goal in the areas of cloud computing, AI and cybersecurity, is for EU companies and citizens to **achieve digital sovereignty**, which represents Europe's ability to act independently in the digital world. Digital sovereignty should be understood not only in terms of protective mechanisms (e.g. the GDPR and AI act), but also offensive tools to foster digital innovation (including in cooperation with non-EU companies), such as attracting foreign investment and retaining digital talent.[266]

All policy measures involving cloud computing, AI and cybersecurity are to some degree ascribable to the EU's Digital Compass strategy, which aims to foster the digitalisation of business by increasing tech uptake among EU companies and SMEs; grow scale-ups and financing opportunities to double the number of European unicorns; and ensure that at least 90% of SMEs achieve a basic level of digital intensity.[267]

In **cloud and edge computing**, the EU is focusing on two lines of action: the promotion of European cloud solutions on the one hand and the quest to advance interoperability on the other.[268] An example is the SIMPL project, an open source, smart and secure middleware

[265] See for instance: https://www.enisa.europa.eu/topics/certification.

[266] European Parliament. (2020). *Digital sovereignty for Europe.* Available at: https://www.europarl.europa.eu/RegData/etudes/BRIE/2020/651992/EPRS_BRI(2020)651992_EN.pdf.

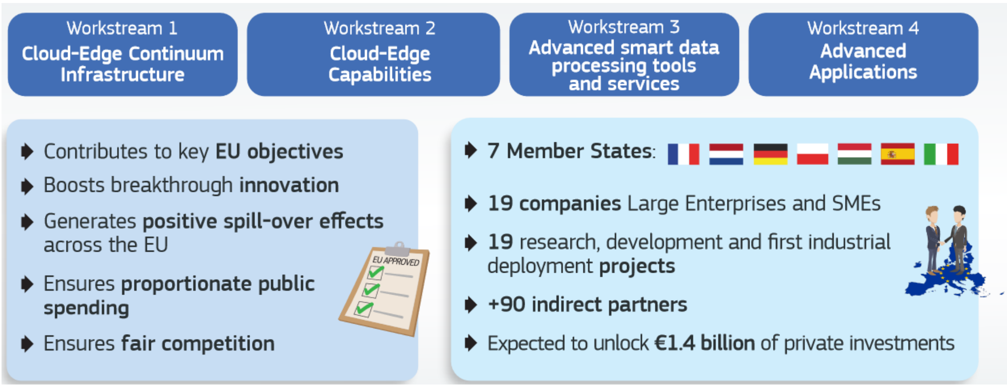
[267] European Commission. (2024). *Digital Decade – Targets and objectives.* Available at: https://digital-strategy.ec.europa.eu/en/policies/europes-digital-decade#tab_1.

[268] Clingendael. (2024) *Too late to act? Europe's quest for cloud sovereignty.* 2024. Available at: https://www.clingendael.org/sites/default/files/2024-02/Policy_brief_Cloud_sovereignty.pdf.

platform that supports data access and interoperability among European data spaces.[269] The European Alliance for Industrial Data and Cloud plays a key role in bringing together the key industrial actors with the Member States' public institutions. The Alliance aims to establish a competitive European cloud supply by supporting the deployment of pan-European cloud marketplaces and defining common requirements for cloud service providers operating in the EU market. However, as an interviewee stated, without fixing the discriminatory effects of unfair software licensing, as demonstrated by Microsoft and Broadcom, these projects might be of limited value in supporting a vibrant community of EU SMEs in the cloud space.

For SMEs, one of the main instruments is the IPCEI (Important Project of Common European Interest) on Next-Generation Cloud Infrastructure and Services, approved by the European Commission in December 2023,[270] and which followed the Roadmap for Next Generation Cloud-Edge published in July 2023.[271] **The IPCEI will provide up to EUR 1.2 billion in public funding to 19 companies (and over 90 indirect partners, 35 of which are SMEs)** across 7 Member States (including 3 SMEs), and is expected to unlock a further EUR 1.4 billion in private investment (see Figure 21). The IPCEI aims to address one of the key vulnerabilities in the value chain – the lack of interoperability across cloud service providers – while exploiting the nascent area of edge computing in order to provide EU companies with a first-mover advantage. The IPCEI will further aim to support the uptake of technologies such as AI across SMEs. According to an interviewee, **such IPCEIs are important, especially because private investment in this sector in Europe has not produced significant results so far.**

Figure 21. IPCEI on next generation cloud infrastructures and services, 2023



Source: European Commission.[272]

Another area in which the EU is trying to involve EU companies – including SMEs – is **public procurement**. For instance, the recent launch of the CLOUD III DPS, a dynamic purchasing system for the adoption of cloud services in European institutions,[273] is an important opportunity for EU cloud service providers to engage with public authorities and expand their market in this field. However, according to an interviewed SME representative, such pan-European tender opportunities are not yet SME-friendly, due to the huge administrative burdens they entail, which lead SMEs to be relegated to sub-contracting or supporting roles.

---

[269] See: https://digital-strategy.ec.europa.eu/en/policies/simpl.

[270] European Commission. (2023). IPCEI on Next-Generation Cloud Infrastructure and Services to boost Europe's Digital Decade. Available at: https://digital-strategy.ec.europa.eu/en/news/ipcei-next-generation-cloud-infrastructure-and-services-boost-europes-digital-decade.

[271] European Commission. (2023). European Alliance for Industrial Data, Edge and Cloud presents its first deliverables. Available at: https://digital-strategy.ec.europa.eu/en/news/european-alliance-industrial-data-edge-and-cloud-presents-its-first-deliverables.

[272] European Commission. *Apoproved IPCEI Next Generation Cloud Infrastructure and Services.* 2023. Available at: https://competition-policy.ec.europa.eu/state-aid/ipcei/approved-ipceis/cloud_en.

[273] European Commission. (2024). Commission launches a new procurement process for Cloud Services. Available at: https://commission.europa.eu/news/commission-launches-new-procurement-process-cloud-services-2024-02-07_en.

To foster involvement in **AI-based technologies**, the Commission launched, in January 2024, the AI innovation package to support Artificial Intelligence start-ups and SMEs, for instance, by granting them access to AI-dedicated supercomputers to facilitate the development of new AI software in the EU, the so-called 'AI factories'.[274] In particular, the Commission aims to finance AI-related activities in various ways:[275]

- AI factories will be financed through the EuroHPC JU, Commission and Member States will invest a total amount of EUR 2.1 billion in acquiring new or upgrading existing EuroHPC supercomputers with AI capabilities. Interviewees also suggested IPCEI-like actions to develop high-performance computers for AI and keep the cost factor at the kind of acceptable threshold for SMEs and startups to access those data in such a way to build infrastructure that is competitive with hyperscalers, but not more expensive.
- The Commission will also provide financial support for start-up incubation and scale-up activities of EUR 100 million via InvestEU.
- Under Horizon Europe and the Digital Europe Programmes, the Commission will support the development of novel use cases and emerging applications in several industrial and societal sectors for an estimated amount of EUR 500 million by 2027. For instance, Digital Europe will fund 75% of the costs for AI uses for imaging systems and high-performance computing for fine-tuning foundational models.[276] An example is the recent Large AI Grand Challenge, which provides EUR 250,000 in prize money and exclusive access to Europe's top supercomputers (LUMI and Leonardo) to develop generative AI tools.[277]

The EU AI Act of December 2023 will also put in place a system to support the uptake of trustworthy AI. In particular, the Act will regulate the larger foundation models, thus giving more certainty to SMEs downstream that want to employ these models about their trustworthiness.[278] However, according to some estimates, the AI Act may also involve significant compliance costs for SMEs, especially among those setting up an entirely new Quality Management System.[279] In particular, according to a VDMA (Germany's Mechanical Engineering Industry Association) position paper, the wording of the AI Act makes it so that it could apply to all possible contexts, which is not only confusing but may also deter innovators and investors alike from developing AI software within the EU.[280]

According to interviewees, **the EU is also trying to encourage the involvement of private investors**, for instance, through bilateral meetings between Adra (the AI and robotics association) on the one hand, and the European Investment Fund (EIF) and European Investment Bank (EIB) on the other. The major interest from investors concerns the funding of start-ups that have a good use case and address different application layers, but not those that want to build language models, European versions of which are already present in Europe, such as France-based Mistral.[281] **The goal is to make it as easy as in the US for start-ups to find private investors**. In fact, interviewees agreed that start-ups are less likely to seek out

---

[274] European Commission. (2024). Commission launches AI innovation package to support Artificial Intelligence start-ups and SMEs. Available at: https://ec.europa.eu/commission/presscorner/detail/en/ip_24_383.

[275] European Commission. (2024). *COM(2024) 28 final – Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions on boosting start-ups and innovation in trustworthy artificial intelligence.*

[276] See the 2023-2024 Work Programme: https://digital-strategy.ec.europa.eu/en/activities/work-programmes-digital.

[277] See: https://aiboost-project.eu/large-ai-grand-challenge/.

[278] DIGITALSME. (2023). AI Act: the EU agrees on rules to support the uptake of trustworthy AI. Available at: https://www.digitalsme.eu/ai-act-the-eu-agrees-on-rules-to-support-the-uptake-of-trustworthy-ai/.

[279] Hilliard, A. And Gulley A. (2023). What considerations have been made for SMEs under the EU AI Act?. Available at: https://www.holisticai.com/blog/how-will-smes-be-supported-under-the-eu-ai-act.

[280] VDMA. (2024). *EU-Regulation: Time to rethink*.

[281] See: https://mistral.ai/.

public funding due to the bureaucratic hurdles it entails: public funding, by definition, entails administrative procedures, and smaller and newer start-ups, with just 5-10 people, may not be able to invest resources to learn about these procedures, leaving no time for the main research projects. The interviewees also noted that a lot of **SMEs and start-ups are less interested in public funding programmes and more concerned about finding information about the kind of challenges they might face, like regulatory compliance, access to data, access to computing, to VC funds to scale up**, etc.

When it comes to **cybersecurity**, the EU budget dedicates some resources from Horizon Europe and the Digital Europe Programme. The latter, in particular, reserves EUR 169.5 million for actions related to operational cooperation and situational awareness, security operation centres, information-sharing and analysis centres, and the Joint Cyber Unit. The funding conditions are particularly favourable to SMEs, which can obtain up to 75% co-funding rate against 50% for other beneficiaries.[282] The business association DIGITALSME and the European Cybersecurity Competence Centre and Network both provide a repository of all funding opportunities for SMEs in this field.[283] Beyond these programmes, the European Innovation Council (EIC) also offers support targeted to SMEs through its Pathfinder accelerator.[284] While the EIC is not cybersecurity-specific, according to an interviewee, there have been talks to develop more cybersecurity-relevant initiatives for the EIC.

However, contrary to other technologies such as cloud and edge computing, interviewees dismiss the utility of IPCEIs for cybersecurity. Many of the Horizon and Digital Europe Programme projects already foresee cross-country projects involving at least three Member States to receive funding, thus creating flexibility to adapt to the market needs of the applying countries. Member States also tend to co-fund a considerable share of these projects, 50% or 75% - sometimes even 100%, according to the interviewee. The European Cybersecurity Competence Centres and Networks (ECCC) already act as coordinating entity across Member States, providing a decentralised source of information and funding. However, this decentralisation in the architecture of funding is important because it allows for flexibility by making the funding closer to the needs of the local markets, SMEs, and national ecosystems.

Private investment from venture capital (VC) still lags behind compared to other countries, but according to an interviewee, there are already **semi-governmental VCs that are partly being funded by national development banks in order to reduce the risk**. An example mentioned is the development in this direction based on an investment facility along the lines of the Cassini Investment Facility, which enables risk capital investments in space-related companies at the level of EUR1 billion or more during the coming six years.[285]

In September 2022, the Commission introduced the **Cyber Resilience Act**, with two main objectives: creating the conditions for the development of secure products with digital elements; and creating the conditions to allow users to take cybersecurity into account when selecting products with digital elements.[286] According to the impact assessment, SMEs would be impacted by the new requirements both as manufacturers and end-users. In particular, SMEs would be more affected than large companies in terms of compliance costs; but at the same time, SMEs would strongly benefit from the Act as users. **As manufacturers, SMEs would benefit the most from having seamless access to the internal market with further**

[282] EIB. (2022). *European Cybersecurity Investment Platform*. Available at: https://www.eib.org/attachments/lucalli/20220206-european-cybersecurity-investment-platform-en.pdf.

[283] See: https://www.digitalsme.eu/funding-opportunities/.

See: https://cybersecurity-centre.europa.eu/funding-opportunities_en.

[284] See: https://eic.ec.europa.eu/eic-funding-opportunities/eic-pathfinder_en.

[285] See: https://defence-industry-space.ec.europa.eu/cassini-space-investment-facility-2022-04-26_en.

[286] European Commission. (2022). Cyber Resilience Act. Available at: https://digital-strategy.ec.europa.eu/en/library/cyber-resilience-act.

reduction in the fragmentation of the digital single market.[287] This is also supported by insights from interviewees, according to whom addressing the fragmentation of the digital single market is a key issue in improving the competitiveness of European SMEs.

More recently, DIGITALSME has begun issuing the **Cybersecurity Made in Europe label**, which provides three benefits to SMEs: it sets the company apart from the bulk of the current cybersecurity offering, thus bolstering their market position; it provides better standing vis-à-vis the digital sovereignty issues, which may be appreciated by several European customers that employ sensitive data; and will raise awareness about the label, thus contributing to stronger collaborative efforts among EU companies.[288]

To address the lack of digital skills, **the EU is also promoting upskilling initiatives** in AI and cybersecurity with AISkills[289] and the Cybersecurity Skills Academy.[290] An example of a successful collaboration between academia and SMEs to improve digital skills in cybersecurity is presented in Box 17. Much is being done also with regard to initiatives in higher education, such as Cyberus, the Joint Master Programme in cybersecurity among France, Estonia, Belgium and Luxembourg.[291] However, interviewees recognised that skilling is an issue that affects not only AI or cybersecurity, but the entire digital ecosystem, and even other areas where skilled work is needed. The risk is that, even with the initiatives promoted by the Pact for Skills, which also involve the likes of AISkills, Europe may still fail to meet the required demand for labour due to its ageing population. In cybersecurity, especially, this is a global risk: according to the Global Cybersecurity Outlook 2024 by the World Economic Forum, only 15% of all organisations are optimistic that cyber skills and education will significantly improve in the next two years, and 52% of public organisations state a lack of resources and skills as their biggest challenge when designing for cyber resilience.[292]

Box 17: Academia and SME collaboration on cybersecurity – an example from Germany

The Cyber Security in the Age of Large-Scale Adversaries cluster of excellence was established in 2019 with more than EUR 30 million in funding and represents a further addition to the cybersecurity ecosystem in North Rhine-Westphalia.[293] This close academia–industry cooperation has resulted in a dense network of information and communications technology (ICT) and cybersecurity SMEs, which in this state alone account for almost a third of all the major German blue-chip companies and Germany's IT security providers.

Source: European Investment Bank.[294]

Aside from EU-level measures, the Member States' governments have introduced several other measures to foster the involvement of SMEs in the value chains for the three

[287] European Commission. (2022). *SWD(2022) 283 final – Executive summary of the impact assessment report.* Available at: https://digital-strategy.ec.europa.eu/en/library/cyber-resilience-act-impact-assessment.

[288] See: https://www.digitalsme.eu/cybersecurity-label/.

[289] AISkills. (2023). *Analysis of relevant practices and initiatives*. Available at: https://aiskills.eu/wp-content/uploads/2023/11/ARISA-Analysis-of-relevant-practices-and-initiatives.pdf.
DIGITALSME. (2024). AI Skills Strategy for Europe: A thorough scheme to match industry needs with an AI-skilled workforce. Available at: https://www.digitalsme.eu/ai-skills-strategy-for-europe-a-thorough-scheme-to-match-industry-needs-with-an-ai-skilled-workforce/.

[290] See: https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/digital-2023-skills-05-cyberacademy.

[291] See: https://master-cyberus.eu/.

[292] World Economic Forum. (2024). *Global Cybersecurity Outlook 2024.* Available at: https://www.weforum.org/publications/global-cybersecurity-outlook-2024/.

[293] See: https://casa.rub.de/en/.

[294] EIB. (2022). *European Cybersecurity Investment Platform*. Available at: https://www.eib.org/attachments/lucalli/20220206-european-cybersecurity-investment-platform-en.pdf.

technologies. These efforts are part of the National Resilience and Recovery Plans, which require that 20% of the funding from the Recovery Facility Fund be allocated for the digital transition. Some of the most relevant measures addressed to SMEs are shown in Table 6 below, although it appears that **most of these measures are aimed at enhancing the uptake of specific technologies rather than generating new software and fostering scale-ups**. Overall, at least 44 different measures have been taken that target SMEs (10-249 employees) among EU Member States, between national strategies, networking platforms, public consultations, AI-related regulations, grants, access to data, AI computing R&D, knowledge transfers, etc.[295]

Table 6. Examples of policy measures from selected NRRPs

Country	Technology	Measure and main goals	SME-specific?
France	AI	Supporting first AI projects that positively impact the company's medium-term development through external services provided by competitive sector entities or by hiring individuals with at least a bachelor's degree level in AI or related fields, for a minimum duration of 12 months. Subsidies will cover up to 50% of eligible expenses for external services or recruitment.	Up to mid-caps: subsidies available for companies with fewer than 2,000 employees, based in the Grand Est region, that are new to AI implementation and have not previously received AI-related aid..
France	AI	Personalised advisory support on the theme of artificial intelligence from experts over a period of 37 days.	Yes
France	AI	This initiative aims to assist entrepreneurs in incorporating artificial intelligence solutions into their businesses. The program includes an initial discovery and training on AI solutions, a diagnostic phase to identify growth opportunities through AI, advisory services for selecting and implementing AI solutions, and support for the operational deployment of AI technologies.	Up to mid-caps: French companies from all sectors; priority given to those with 10-2,000 employees and a turnover exceeding EUR 250,000.
France	Cybersecurity	Training organised by the Hauts-de-France Chamber of Commerce and Industry on several cybersecurity topics to enable SMEs to enhance their skills: Awareness Key players and resources Potential threats Best practices	Yes
Italy	Cloud	EUR 2.5 million for the creation of a single cloud platform available to start-ups and dedicated to their development. This platform will contain all the information useful for their establishment, from the development of the innovative idea through a business plan to support in planning and taking care of key aspects, to the indication of the regulatory and economic requirements essential for recognition, for registration in the Companies Register and for access to incentives and facilities.	Yes
Italy	AI	EUR 110 million for training aimed at the creation and strengthening of an 'Ecosystem of Innovation' RAISE (Robotics and AI for Socio-economic Empowerment), a network of research institutions and leading local R&D companies.	Yes
Slovakia	Cybersecurity	~EUR 74 million for the construction of competence centres and platforms focused on specific technologies. Building these centres will be a stimulus for the whole industry, as they will provide services that are already in demand but for which there is no supplier in Slovakia (e.g. high-performance computing, blockchain or cybersecurity).	Also includes R&D centres
Spain	Cybersecurity	Completion of the projects in the National Cybersecurity Industry Support program, the Global Security Innovation Programme and related actions involving: boosting the national cybersecurity industry for the emergence, growth and development of businesses developing high value-added solutions and services train and develop talents Internationalisation actions setting up of a demonstration centre for cybersecurity infrastructure development and creation of new cybersecurity services including test laboratories and	Yes

[295] See: https://oecd.ai/en/dashboards/target-groups/TG31.

Country	Technology	Measure and main goals	SME-specific?
		cybersecurity attack simulators development of cybersecurity label certifications	

Source: authors' elaboration.
Note: IPCEI actions excluded.

Beyond the NRRPs, some national initiatives also promote the diffusion and development of digital technologies, especially among SMEs and start-ups.[296] For instance, in **Austria**, the aws digitalization programme supports the first-time implementation of trusted AI projects in SMEs in collaboration with a cooperation and implementation partner through non-repayable grants up to 50% of the eligible project costs and up to EUR 15,000 for a total of 9 months.[297] In **Poland**, the CyberMarket 2024 competition organised by the National Cybersecurity Competence Center (NCC-PL) provides an opportunity to provide the best solution in the field of cybersecurity, and meet entrepreneurs and investors.[298] Also in **Poland**, the National Cloud Operator (NCO) launched in 2018 a joint venture between major Polish banks and the Polish Development Found. The NCO aims to create a secure, sovereign cloud infrastructure tailored to meet the needs of public administration, education, and business sectors, including SMEs. The infrastructure supports the adoption of cloud services that are secure and compliant with EU data protection standards.[299] In **Sweden**, the agency Vinnova, through the Advanced Digitalisation programme, has funded about 100 projects, with 62 more on the way to develop advanced, sustainable digital solutions that increase the competitiveness of Swedish industry. Between 2023 and 2027, the Advanced Digitalisation programme aims to cover projects for around SEK 4.5 billion (approximately EUR 400 million), with half of the funding coming from the public coffers and half from industry. Although the calls are not targeted exclusively at SMEs, they are still directly involved.[300]

Finally, Box 18 below offers some insights on the public investment strategies being undertaken in non-EU countries.

Box 18: Public investment in the US and China

Public investment in the analysed digital technologies (cloud computing, AI and cybersecurity) is significant in both the USA and China, although it is difficult to provide comparable estimates with the EU.

Any international comparison is also rendered more difficult due to the different environments and goals each jurisdiction is setting. For instance, around 70% of the cybersecurity budget in the USA goes through the Department of Defence. Investment in the US in cloud infrastructure is also much higher due to the presence of hyperscalers, with AWS alone spending around USD 108 billion between 2011 and 2022.[301] AI policy in the EU is much more consumer-friendly, which has led to a horizontal approach to AI regulation whereby all industries would be equally interested. In the USA, on the contrary, AI regulation is more

[296] For a list of initiatives and funding specific to the AI landscape, see: https://ai-watch.ec.europa.eu/countries_en. However, like for the NRRPs, most of these measures are aimed at the uptake of AI technologies, rather than their development.
[297] aws digitalization. (2024). aws Digitalization - special Terms/Conditions AI-Start Green. Available at: https://www.aws.at/en/aws-digitalization/ai-start/.
[298] See: https://www.gov.pl/web/cyfryzacja/ruszyl-konkurs-cybermarket-2024.
[299] See: https://ochk.cloud/.
[300] See: https://www.vinnova.se/en/m/digital-transformation/advanced-digitalisation---programme-for-future-solutions-in-swedish-industry/.
[301] Data Center Frontier. (2023). AWS Says U.S. Cloud Computing Infrastructure Investment Exceeds $108 Billion. Available at: https://www.datacenterfrontier.com/cloud/article/33013122/aws-says-us-cloud-computing-infrastructure-investment-exceeds-108-billion.

vertical, i.e. more sector-based. Finally, in China AI regulation is focused on supervision of AI-generated content and the defence of domestic companies in the market.

Below, we provide more details about public investment in the USA and China. **Many of these technologies also rely on the latest advances in computing, including quantum computing.** According to a recent report from Fortune, China is committing around USD 15 billion in the field, more than double what the EU pledged and around eight times what the US government is planning to spend.[302]

Cloud and edge computing

In China spending on cloud infrastructure was more than USD 9 billion for 2023, accounting for 12% of global cloud spending.[303] **In the USA**, the government is also undertaking significant investment in cloud infrastructure, with **federal spending rising to nearly USD 15 billion per year** in 2023, reflecting a substantial financial commitment to cloud computing and related services.[304] In both cases, this substantial investment in cloud infrastructure is aimed at making sure domestic capacity for running AI software, some policies for which are described below.

Artificial intelligence

The USA and China are leading the race in AI development: the USA has created potential award values of public contracts worth up to USD 4.5 billion between 2022 and 2023, particularly for defence applications,[305] while Chinese spending on AI is estimated to be around USD 15 billion for 2023 alone.[306] **In the USA, policy actions are pursuing a strategy similar to Europe's based on safety, security and trustworthiness and aimed at promoting a fair, open, and competitive AI ecosystem** by providing small developers and entrepreneurs access to technical assistance and resources and helping small businesses commercialise AI breakthroughs.[307] However, instead of taking a horizontal approach, the US legislation is more vertical in nature, applying to specific industries. In parallel, some congresspeople have advanced an innovation framework for AI that aims, among other things, **to increase national security protections**, including export controls, sanctions, and other restrictions to prevent foreign adversaries from obtaining advanced AI technologies.[308] This has already happened with China, with the US implementing restrictions on exporting advanced artificial intelligence to China and other countries, including Iran and Russia.[309]

For its part, **Chinese policy has sought to proactively foster domestic AI capabilities—** which it sees as critical to the country's economic development—**while imposing robust**

302 Fortune. (2024). America is the undisputed world leader in quantum computing even though China spends 8x more on the technology–but an own goal could soon erode U.S. dominance. Available at: https://fortune.com/2024/04/12/america-undisputed-world-leader-quantum-computing-even-though-china-spends-technology-us-dominance/.

303 Canalys. (2023). *Mainland China's cloud market spending up 18% in Q3 2023 as growth rate stabilizes*. Available at: https://canalys.com/newsroom/mainland-china-cloud-market-q3-2023.

304 InfoWorld. *Cloud infrastructure spending is growing*. 2023. Available at: https://www.infoworld.com/article/3708269/cloud-infrastructure-spending-is-growing.html.

305 Brookings. *The evolution of artificial intelligence (AI) spending by the U.S. government*. 2024. Available at: https://www.brookings.edu/articles/the-evolution-of-artificial-intelligence-ai-spending-by-the-u-s-government/.

306 DW. *AI: How far is China behind the West?*. 2023. Available at: https://www.dw.com/en/ai-how-far-is-china-behind-the-west/a-66293806 .

307 White House. *FACT SHEET: President Biden Issues Executive Order on Safe, Secure, and Trustworthy Artificial Intelligence*. 2023. Available at: https://www.whitehouse.gov/briefing-room/statements-releases/2023/10/30/fact-sheet-president-biden-issues-executive-order-on-safe-secure-and-trustworthy-artificial-intelligence/.

308 Inside Global Tech. *Spotlight Series on Global AI Policy — Part II: U.S. Legislative and Regulatory Developments.* 2023. Available at: https://www.insideglobaltech.com/2023/10/23/spotlight-series-on-global-ai-policy-part-ii-u-s-legislative-and-regulatory-developments/.

309 Reuters. *Biden cuts China off from more Nvidia chips, expands curbs to other countries.* 2023. Available at: https://www.reuters.com/technology/biden-cut-china-off-more-nvidia-chips-expand-curbs-more-countries-2023-10-17/.

regulations and technical standards to contain perceived risks.[310] Much of its policy is focused on the supervision of AI-generated content.[311] Most relevant, foreign AI companies have not yet received any approval to release their products in China (and likely won't in the future). As a result, **the domestic commercial environment protects Chinese companies**. It may help them gain an edge against Western AI companies, but it may also stifle competition and reinforce China's control of online speech.[312]

Cybersecurity

As one of the major world powers, the USA is often a target of cybersecurity attacks. **For the fiscal year 2023, it allocated USD 15.6 billion for cybersecurity**, the majority of which (USD 11.2 billion) was appropriated by the Department of Defence.[313] Although most of this funding will go to public agencies, the government also plans to invest in the private sector. In particular, with the 2023 National Cybersecurity Strategy, the US government aims to forge a new social contract in which the private sector is responsible for protecting the nation's cybersecurity. Government power will be used to re-align incentives and shape the market through a combination of carrots of government funding and sticks of regulation.[314]

China's cybersecurity narrative is deeply embedded in, and a manifestation of, its broader national security vision, while its international ambitions in the matter are far more limited.[315] **No straightforward figures on public investment in cybersecurity are available**, though this is likely due to strong overlap with national security measures.

Source: authors' elaboration.

[310] Inside Global Tech. *Spotlight Series on Global AI Policy — Part III: China's Policy Approach to Artificial Intelligence.* 2023. Available at: https://www.insideglobaltech.com/2024/02/08/spotlight-series-on-global-ai-policy-part-iii-chinas-policy-approach-to-artificial-intelligence/

[311] HolisticAI. *Making Sense of China's AI Regulations*. 2023. Available at: https://www.holisticai.com/blog/china-ai-regulation.

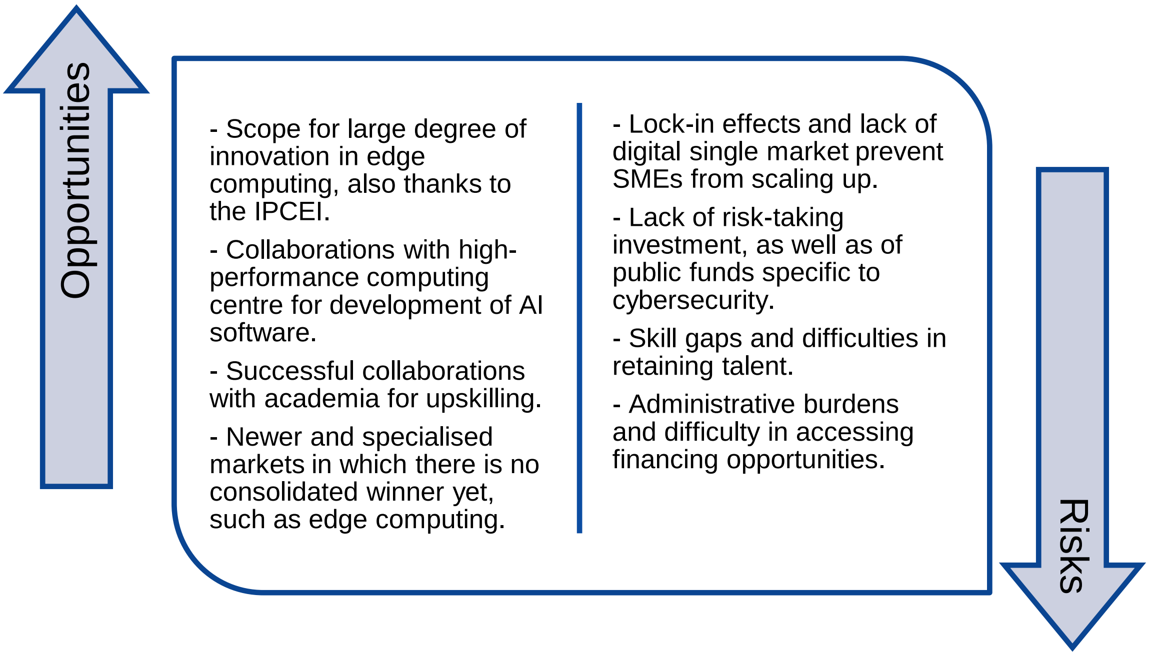
[312] MIT Technology Review. *What's next for AI regulation in 2024?*. 2024. Available at: https://www.technologyreview.com/2024/01/05/1086203/whats-next-ai-regulation-2024/.

[313] Security Intelligence. *How much is the U.S. investing in cyber (and is it enough)?*. 2023. Available at: https://securityintelligence.com/articles/how-much-is-us-investing-in-cyber/.

[314] Williams, B.K. *Biden to private sector: Cybersecurity is your responsibility—not the user's*. 2023. Available at: https://cisac.fsi.stanford.edu/news/biden-private-sector-cybersecurity-your-responsibility-not-users.

[315] Creemers, R. The Chinese Conception of Cybersecurity: A Conceptual, Institutional, and Regulatory Genealogy. *Journal of Contemporary China, 33*(146). 2023. Pp. 173-188.

Figure 22. Opportunities and risks for SMEs from higher strategic autonomy in cloud/edge computing, AI and cybersecurity



5.3 Recommendations for future policy action

Following the above analysis of the value chains in cloud/edge computing, AI and cybersecurity, as well as their vulnerabilities, opportunities and risks, and ongoing measures and projects, the following recommendations can be made:

Cloud and edge computing

- **Provide a solution to unfair licencing practices.** One of the heaviest financial and operational burdens to smaller cloud service providers is represented by the subservient relationship that SMEs have vis-à-vis hyperscalers when it comes to software licencing. It is the biggest contributor to SMEs' competitiveness in the cloud space. One way to tackle these unfair practices is through antitrust, which can however be lengthy and costly for SMEs. An alternative solution would be the extension of the Digital Markets Act (DMA) to software (e.g. VMware), which could be regarded as 'gatekeeper' in order to provide fairer business practices in the sector.
- **Foster the usage of inter-operable software at all stages of the value chain**. The usage of open-source software is, to date, limited to individual stages in the value chain. The creation of a comparable alternative to the vertical integration offered by hyperscalers would allow European cloud SMEs to expand their markets without suffering from unfair licensing practices. This promotion could, for instance, take the form of financial support to incentivise the uptake of open-source software during the transition period (since switching from one software to the other is costly and time-consuming). For instance, some of these actions could be taken through public procurement competition for European data spaces. Such incentives would also work in parallel with legislation such as the Data Act, which aims to remove costs for switching between cloud service providers.
- **Focus on specialised applications and cutting-edge technologies.** Multi-cloud platforms, edge and cross-sectoral software applications offer important opportunities

for SMEs compared with investment for infrastructure, which is very costly and dominated by larger firms. Some successful ongoing projects suggest that there may be available market space here, especially for those SMEs at the technological forefront. Policy-makers could then engage with stakeholders for co-creation solutions aimed at identifying market gaps and opportunities for European cloud service providers and SMEs involved in cloud and edge computing technology.

- **Create national SME advocates to foster SMEs' participation in pan-European projects.** Large pan-European projects are difficult for SMEs to access due to the significant administrative burdens they entail in terms of supporting documentation and financial and technical resources. This leads SMEs to lose their seat at the table. Even the presence of specialised figures within the company may not be enough to scratch the surface regarding project management, according to an interviewee. A way to ensure SMEs have a loud voice in the matter would be for specialised national SME advocates to assist SMEs in matters of procurement and institutional consultations. An example is represented by the French pôles de compétivité, such as CAP Digital.[316] National trade associations could also play a role, although, according to an interviewee, they are too broad-based and not specialised enough to provide all the necessary support.
- **Ease the regulatory burden.** In a recent White Paper, the Commission proposed to extend telco rules to cloud providers and their private networks in the area of dispute resolution and access regulation, arguing that large telcos are at a competitive disadvantage in the cloud space compared to European cloud service providers.[317] However, such a proposal could further hinder the ability of small EU cloud providers to compete against hyperscalers or large incumbent telcos.
- **Make access to financing easier.** Investment in innovation facilities is paramount to fostering SMEs' participation in new cloud and edge technologies. However, public funding is fragmented, and the administrative burdens are significant. A one-stop shop to educate SMEs in cloud computing about funding opportunities and the financing process would go a long way in fostering their participation. For instance, DIGITALSME recently proposed a one-stop shop for SMEs and a Tech Champions Fund for companies on the verge of market leadership that could incentivise reskilling and upskilling for SMEs, leveraging on structured alliances, such as Large-Scale Partnerships under the Pact for Skills.[318]

AI

- **Encourage digitisation of data among SMEs.** To encourage the adoption of AI by SMEs, it is a priority to support their investment in digitisation for internal data collection, along with tax deductions for innovative technologies and the hiring of specialised profiles, to make them ready to adopt and fully exploit the potential of AI.[319] Such measures would then go hand-in-hand with the goals of the Digital Decade.
- **Encourage private investment in start-ups in the sector.** Europe lacks a culture of risk taking, which makes private investors far more cautious and less interested in

[316] See https://www.capdigital.com/.

[317] European Commission. *How to master Europe's digital infrastructure needs.* 2024. Available at: https://digital-strategy.ec.europa.eu/en/library/white-paper-how-master-europes-digital-infrastructure-needs.

[318] DIGITALSME. *Manifesto 2030. DIGITAL SME calls for a European Digital New Deal.* 2024. Available at: https://www.digitalsme.eu/manifesto-2030-digital-sme-call-for-a-european-digital-new-deal/.

[319] *Ibidem*

potentially disruptive start-ups. Encouraging private investors should, however, go in steps:

- Raise visibility among start-ups and investors about successful investments in the EU, which may serve as best practices for future undertakings. This could be done, for instance, by promoting EU websites such as AI on Demand (https://aiod.eu/) and collaborating with other directorate generals and national and European associations.
- Spread awareness of such initiatives and funding information (both public and private) through forums gathering innovators and other stakeholders. Use the opportunity to make start-ups aware of the regulatory challenges on compliance with the AI Act, access to supercomputing and quality data, networking with private investors, etc.
- Promote risk-taking among investors by engaging financial institutions such as the EIB and the EIF to provide de-risking.

- **Simplify the process for non-EU start-ups to set up shop within the EU.** This measure would stimulate greenfield foreign investment on the continent (as opposed to brownfield M&A, which only redirects the value added elsewhere). The creation of a European innovation passport would define the status of a European innovation company as being subject to a single tax regime, uniform administrative procedures, and coordinated labour policies aimed at retaining talent.[320]

- **Focus regulation on where risks exist.** The AI Act may actually stifle the innovation of SMEs at the technological forefront because of its sweeping requirements that could apply to any possible context in which generative AI may be included. This, in turn, could also deter future investors from supporting European SMEs and start-ups. A more focused regulation that addresses those risks that companies can actually influence would have less detrimental effects on innovation and investment.[321]

- **Provide incentives to skilled workers to come to and remain in the EU Member States.** The current skilled workforce in the Union is not enough to satisfy the likely increasing demand. The EU needs to provide competitive incentives for AI specialists to come to and remain in Europe. Salary alone would not work, given the stronger financial capabilities of US companies. Another hurdle is the existence of 27 different regulatory processes that make the choice for non-EU talent difficult. Hence, Member State governments would do well to rethink their visa programmes to attract foreign talent. For instance, simplified immigration and integration procedures for foreign talent would make the choice much easier. Two examples from the Netherlands, Denmark and Italy could be taken as best practices:
    - In the Netherlands, the government offers tax exemptions on 30% of an employee's gross qualifying income or allows them to reimburse actual extraterritorial expenses incurred by the employee for a period of 60 months.[322]

[320] Bianchini, N. & Ancona, L. *Artificial intelligence: Europe needs to start dreaming again.* 2023. Available at: https://www.robert-schuman.eu/en/european-issues/728-artificial-intelligence-europe-needs-to-start-dreaming-again.

[321] VDMA. *EU-Regulation: Tme to rethink*. 2024.

[322] See: https://www.ags-relocation.com/news/netherlands-tax-changes-explained/. The Dutch government has recently approved some changes that limit the scope of this measure. Since 1st January 2024, expatriates eligible for the ruling will only benefit from a sliding scale tax benefit of 30% for the initial 20 months, then 20% for the next 20 months, and finally 10% for the final 20 months. The ruling can be used for a maximum salary of EUR 233,000 (in 2024).

  - In Denmark, researchers and highly paid employees can apply to be taxed under the tax scheme for researchers. Employees registered under the scheme pay tax at a rate of 32.84% instead of the ordinary tax scheme of up to 55.9%[323]
  - In Italy, researchers returning from abroad are only subject to a 10% taxation rate for the following 5 years.[324]

  Although these measures are aimed more specifically at researchers, in some cases SMEs involved in R&D activities may still use them. SMEs can also benefit directly from these schemes: some countries (Belgium, France, Netherlands) specifically offer R&D tax credits and exemptions on wages for SMEs and start-ups.[325] It is important not to extend such measures for an excessive amount of time (ideally no longer than five years). This would not only ensure that such measures do not constitute an excessive fiscal burden to the government's coffers, but also reduce the probability of occurrence of negative spillovers (e.g. distortion of competition, pricing out of local inhabitants).

- **Simplification of regulatory frameworks.** To accelerate AI deployment among SMEs, it is also necessary to simplify the frameworks under which SMEs can be competitive:[326]
  - avoid undue regulatory burdens on SMEs through simplified processes for SMEs;
  - promote private sector investment by setting up a European AI Venture Capital scheme to support SMEs developing critical AI applications in their growth phase. A one-stop shop for access to funding, as described above, would also be beneficial to SMEs;
  - facilitate joint investments by SMEs with similar or complementary needs for AI solutions. This could take the form of mere match-making (e.g. by providing a kind of directory that allows the identification of SME partners with aligned interests) or active financing (e.g. by guaranteeing private sector financing for SME alliances via the EIB or offering dedicated calls for such alliances).

Cybersecurity

- **Creation of a cybersecurity-specific fund.** ECSO (the European CyberSecurity Organisation) proposed a cybersecurity-specific fund of at least EUR 1 billion in order to promote investments in European cybersecurity start-ups and SMEs, as well as keep competencies and strategic solutions within Europe.[327] Such funding is particularly important for SMEs in that they would be more affected than large firms by the Cyber Resilience Act due to the restricted customer base, the lower financial capacity to absorb costs, and the overall lack of economies of scale. Having public funding support readily available for SMEs would greatly reduce these disadvantages.
- **Cybersecurity-specific capital risk private investment tool.** In order to increase the involvement of VCs in the cybersecurity domain, it is essential to provide private

[323] See: https://skat.dk/en-us/businesses/employees-and-pay/non-danish-labour/tax-scheme-for-researchers.

[324] See: https://www.agenziaentrate.gov.it/portale/web/guest/docenti-e-ricercatori-rientrati-in-italia-che-cos-%25c3%25a8-cittadini.

[325] See: https://stip.oecd.org/innotax/incentives?f:active=In%20force%20in%202022&f:taxinst2b=Payroll%2FSSC%20incentives.

[326] European Commission. *Artificial Intelligence – Critical industrial applications: report on current policy measures and policy opportunities.* 2020. Available at: https://op.europa.eu/en/publication-detail/-/publication/fe5a340a-93fb-11ea-aac4-01aa75ed71a1/language-en.

[327] ECSO. *European Cybersecurity Investment Platform (ECIP)*. Available at: https://ecs-org.eu/activities/european-cybersecurity-investment-platform/.

investors with a tool that allows them to inject risk capital in a simple manner. Interviewees suggest action along the lines of the Cassini investment facility. An alternative could be to embed cybersecurity projects more deeply within the Cassini facility to ensure two outcomes: (1) better integration between the digital and space ecosystems; and (2) possibility of dissemination of best practices from the space sector to other cybersecurity domains (e.g. infrastructure, anti-fraud, supply chain security, etc.).

- **Strengthening of the digital single market by addressing its digital fragmentation.** The largest benefit for SMEs as producers of cybersecurity software comes from having seamless access to large end-consumers. In order to do so, it is important that there are no significant regulatory hurdles for software distribution across the Member States or export restrictions. One way to do so is already in action: SMEs can help in this aspect by providing cybersecurity certifications that are applicable across the EU, and which can increase the competitiveness of the firms in the sector.
- **Ensure compliance costs with the Cyber Resilience Act are proportionate to the capacities of the addressees.** SMEs are more likely to bear higher compliance costs with the Cyber Resilience Act. These costs may also spill over to development costs, putting SMEs at a disadvantage vis-à-vis global competitors. Hence, all actors in the EU cybersecurity market, and most saliently SMEs, need to be supported in their ability to innovate and offer high-quality solutions to the European market.[328]

[328] DIGITALSME. *The importance of cybersecurity in the age of AI*. 2022. Available at: https://www.digitalsme.eu/the-importance-of-cybersecurity-in-the-age-of-ai/.

6 OSA and SMEs in the mobility-transport-automotive ecosystem

Highlights:

- Li-ion batteries and fuel cells are key enabling technologies for the green transition. Batteries can be used for stationary energy systems, portable devices, but their biggest market is in automotive. Similarly, fuel cells have both stationary and mobility applications, though the latter are more promising. With three quarters of road pollution due to vehicles, battery- and fuel cell-powered vehicleswill play a pivotal role in reducing CO_2 emissions.
- Although the battery sector is dominated by larger players due to the significant economies of scale required for battery production, SMEs are involved at various stages in the value chain. At the cell component manufacturing stage, SMEs produce components for battery separators; at the cell manufacturing stage, SMEs can provide pilot line testing before larger manufacturers scale production; SMEs are also involved in battery pack manufacturing by producing software such as energy management systems; finally, SMEs are strongly involved in the aftermarket, through maintenance services, and especially recycling, where their role could be further boosted as xEVs will reach their end of life. Most importantly, SMEs can provide tailor-made and niche solutions for the automotive industry, as well as supply the necessary machinery to operate gigafactories.
- In fuel cell manufacturing, SMEs are particularly involved in R&D operations: often larger firms outsource these non-profitable activities to SMEs or start-ups or create joint ventures in order to avoid recording losses in the company books. SMEs are also active in the provision of services for pilot tests, and pioneering work in several sectors such as maritime navigation, aircrafts, and construction for first industrial deployment.
- The main goals the EU is set to achieve open strategic autonomy in the battery value chain are: (1) investment to enhance the EU's refining capabilities; (2) diversification of the supply for raw and processed materials; (3) bolstering of internal capacity in cell manufacturing; (4) stimulation of circularity through recycling; and (5) investment in alternatives to replace current battery technology.
- For the fuel cell sector, the EU aims to achieve four main goals: (1) increasing the efficiency and reducing the costs of fuel cells; (2) adapting system behaviour for specific applications of fuel cells; (3) ensuring the entire life cycle of materials and components is covered through recycling; and (4) standardising fuel cell technologies for different use cases. The biggest hurdles to mass production and deployment of fuel cell vehicles are the lack of infrastructure for refuelling (mostly concentrated in Germany) and the lack of harmonisation and standardisation, which leads to several delays for pilot projects.
- The main EU measures in the battery field are the two IPCEIs on batteries. Both IPCEIs foresee the participation of SMEs and start-ups, as well as several collaborations with external partners. SMEs are involved in a variety of areas, ranging from access to facilities for testing, to knowledge-sharing for the development of advanced materials, and from supply of products for production in gigafactories to involvement in pilot lines for R&D&I to mention a few.

- Likewise, the development of fuel cell technologies is part of three IPCEIs on hydrogen, though the focus on fuel cells is mostly on the first one, Hy2Tech. Within this IPCEI, there is a large scope for scale-ups of current SMEs, with several opportunities for spillovers in the local supply chain, which will lead to more job opportunities.
- Some relevant funding programmes at the EU level are the BATT4EU initiative, the European Innovation Fund for net-zero technologies, and the European Innovation Council operating under the EU Horizon Europe programme.
- The EU has also proposed, in December 2023, a one-stop shop service for guidance to SMEs in the battery industry to access EU finance.
- In the area of fuel cell, most investment is to date confined to R&D activities, including pilot testing. Some relevant programmes are GAIA, ZEFER, JIVE/JIVE2 and 3MOTION to name but a few. The Clean Hydrogen Partnership, under the FP7 and Horizon programmes, has initiated 176 projects focusing on fuel cells, for a total of EUR 866 million, involving 200 SMEs, which received around one quarter of the total funding.
- Policy action to increase benefits and opportunities for SMEs in the battery sector should work in five main direction: (1) making the mechanisms for the implementation of EU funding more efficient; (2) ensuring that public funding is also available to mid-caps, which are most likely to lead the green transition in mobility; (3) providing confidence to investors, possibly by taking advantage of the SME Growth Markets; (4) reinforcing engagement at the local level to ensure that those SMEs who cannot engage with EU-level associations are sufficiently involved; and (5) decreasing the burden of compliance with the battery regulation.
- For fuel cells, policy action aimed at increasing the benefits and opportunities for SMEs could look at: (1) enhancing financial support for programmes aimed at reducing fuel cell costs, increasing well-to-wheel data through testing, and building the necessary infrastructure for long-haul trips; (2) reassuring investors of the market potential for fuel cells, also through stronger assurances on standard-setting; (3) promoting clusters of collaboration and involving more strongly Eastern European Member States; (4) providing certifications ensuring the quality and performance of the technologies to fend off cheaper non-EU alternatives; and (5) promoting alternative uses of fuel cells in sectors such as maritime shipping, aviation, and construction.

This section offers an overview of the main issues related to OSA and SME development in the **mobility ecosystem**. More specifically, the focus is on **batteries** (particularly lithium-ion batteries for electric vehicles (xEVs))[329] and **fuel cells** as alternative technologies for clean mobility. Both batteries and fuel cells are key technologies that the Net-Zero Industry Act, which aims to support the EU's climate-neutrality commitment and the clean energy transition, classifies as commercially viable or soon to enter the market and which have significant potential for rapid scale-up to contribute to the EU's decarbonisation targets.[330]

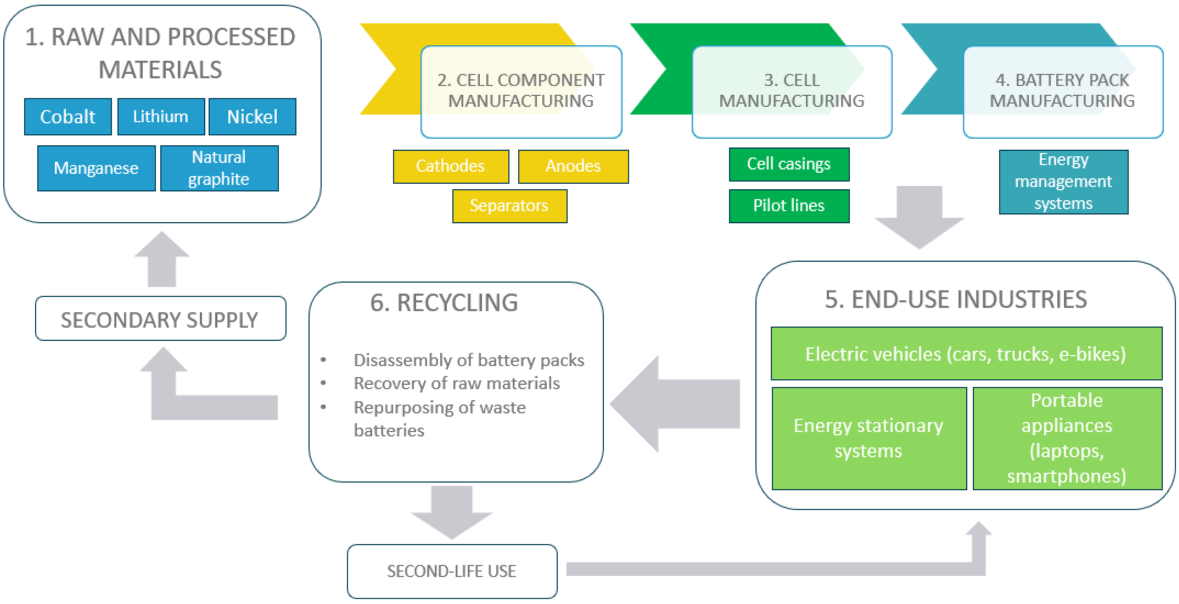
[329] The x refers to the different typology of EV, which may be plug-in hybrids (PHEVs), battery-powered (BEVs) or also powered by fuel cell technology (FCEVs).
[330] European Commission. (2023). The Net-Zero Industry Act: Accelerating the transition to climate neutrality. Available at: https://single-market-economy.ec.europa.eu/industry/sustainability/net-zero-industry-act_en

6.1 Li-ion batteries

6.1.1 Overview of the value chain, positioning of SMEs and strategic vulnerabilities

The value chain for batteries in the mobility ecosystem is divided in at least six key segments, as shown in Figure 23:[331]

Figure 23. Schematisation of the battery value chain



Source: Authors' elaboration.

Battery manufacturing is dominated by larger companies. Battery manufacturers are present across the entire EU, although there are some preferred areas for production location. One is Germany, which represents an attractive location due to its strong automotive industry, which allows battery manufacturers to more easily integrate in the ecosystem (see the example of Tesla's gigafactory near Berlin in Box 22). Another area is represented by Hungary and Poland. These countries are geographically close to Germany (especially regions such as Western Transdanubia in Hungary and Wroclaw in Poland, where many of the factories are located), so they also benefit from the same cluster advantage; they are historically FDI-friendly thanks to favourable government subsidies for regional development;[332] and already host subsidiaries of big Asian players (Samsung, LG) involved in processing and refining for several other industries.[333] Finally, in some cases, cell manufacturers such as Northvolt elected Northern Sweden for their factory site due to the proximity to raw materials needed for battery production, such as graphite and nickel.[334]

While SMEs account for 92% of the total enterprises involved in battery manufacturing (out of around 660 companies), they only employ 16% of the persons in the sector (Figure 24). **One of the major obstacles to SME involvement in battery manufacturing is that the scaling**

[331] Electric vehicle manufacturing is only touched upon briefly in the analysis in order to maintain the focus on the key technology itself.

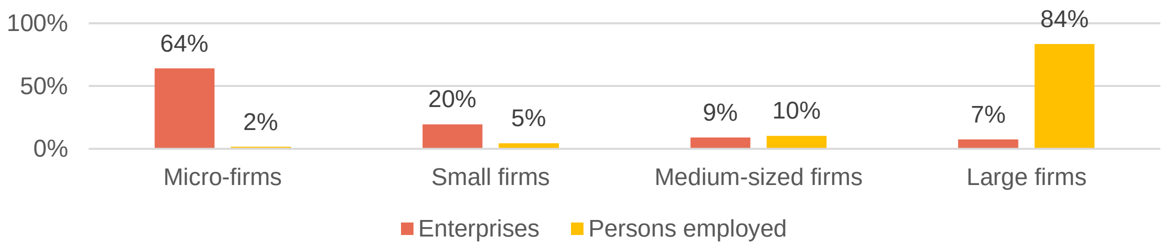
[332] Schito, M. (2022). The effects of state aid policy trade-offs on FDI openness in Central and Eastern European Countries. *International Review of Public Policy*, *4*(4: 2).

[333] Sachwald, F. (2013). *Going multinational: the Korean experience of direct investment*. Routledge.

[334] EIB. (2018). A jolt of green energy for Europe. Available at: https://www.eib.org/en/stories/northvolt-lithium-ion-battery.

of production is very difficult, making it hard for SMEs to directly engage in such activities. According to an interviewee, scaling difficulties arise because the materials' quality needs to be consistently good in large quantities to ensure that cells are uniform or do not present cracks. This is an iterative process that produces a lot of scrap material and requires time and resources until a good level of mastery of the process is achieved. For this reason, some factories are expanding their recycling capabilities to maximise scrap usage, something which most SMEs could ill afford.

Figure 24. Firm breakdown in battery production in the EU-27, 2022



Source: Eurostat table sbs_sc_ovw

Note: Battery production here is understood as NACE code C27.2 ("Manufacture of batteries and accumulators").

European battery producers suffer from several vulnerabilities along the battery value chain. At the level of **raw material extraction and processing**, the EU's import reliance ranges from 86% for cobalt to 100% for natural graphite, while battery-grade material refining is mostly concentrated in China (ranging from 60% of the total global production for refined cobalt, up to 93% for graphite-active materials).[335] Another vulnerability resides in **cell component manufacturing**, with the majority of the companies involved in current or planned component production being non-European, mostly coming from Asia (Korea, Japan, China).[336] The EU is ramping up cell manufacturing production, with at least 16 gigafactories (i.e., factories specialised in battery production) planned to enter operation between 2024 and 2028. These additional factories would increase the production capacity from 175GWh in 2023 to 1,600GWh in 2030,[337] although only 57% of the expected production for 2030 will come from EU capital-backed companies.[338] Although the EU is in line with US production, which was 110GWh in 2022, it pales in comparison with China's 1,200TWh in the same year, which could increase to 4,650GWh by 2030.[339] Moreover, the pipeline for new projects in cell manufacturing in Europe has experienced a decline due to Provision 45X in the Inflation Reduction Act (IRA) of the US (see Box 19).

---

[335] JRC. (2023). *Supply chain analysis and material demand forecast in strategic technologies and sectors in the EU – A foresight study*.
IPCEI-batteries. (2023). *Resilient Supply Chains in the Battery Industry.* Available at: https://www.ipcei-batteries.eu/fileadmin/Images/accompanying-research/publications/2023-03-BZF_Studie_Lieferketten-ENG.pdf.

[336] IPCEI-batteries. (2023). *Build-up of the battery industry in Europe – Status quo and challenges.* Available at: https://www.ipcei-batteries.eu/fileadmin/Images/accompanying-research/market-updates/2023-07-BZF_Kurzinfo_Marktanalyse_Q2-ENG.pdf.

[337] IPCEI-batteries. (2022). *The importance of regional value creation structures in the battery industry.* Available at: https://www.ipcei-batteries.eu/fileadmin/Images/accompanying-research/publications/2022-10-BZF_Clusterstudie_ENG_final.pdf.

[338] ISI Fraunhofer. (2022). *Battery cell production in Europe: In which countries will European manufacturers dominate – and where do international companies want to gain a foothold?*.
Available at: https://www.isi.fraunhofer.de/en/blog/themen/batterie-update/batterie-zell-fertigung-europa-hersteller-europaeisch-international-kapazitaeten-2030.html.

[339] See: https://www.iea.org/data-and-statistics/charts/lithium-ion-battery-manufacturing-capacity-2022-2030.

Box 19: Provision 45X of the Inflation Reduction Act and Chinese competition in the European battery market

Provision 45X of the US Inflation Reduction Act (IRA) introduces generous tax credits for businesses that manufacture and sell energy components.[340] This measure lowers the overall cost of battery production for American firms, putting them on a similar footing as the Chinese producers. The provision also prohibits companies with ties to China from receiving the tax credit, incentivising the entrance into the US market of foreign companies, particularly from Japan and Korea. However, the IRA's generous subsidies are also attracting investment from Europe: in 2023, the Norwegian battery start-up Freyer accelerated its investment plans to invest in a US plant to benefit from the IRA tax credits.[341]

With the US market becoming more difficult to penetrate, Chinese companies are now shifting their attention to Europe, with the European market share of Chinese battery makers jumping from 15% in 2020 to 39% in the first half of 2023, according to the Korean market research firm SNE Research.[342] An example is the recent entry of Chinese automotive giant BYD in the European market of xEVs, with an agreement to build a factory in Hungary, which could lead to around EUR 100 billion in additional FDI to the country, according to the Hungarian Finance Ministry.[343]

There is a geopolitical risk for the EU to this expansion: China has overcapacity when it comes to battery value chains, which is driving down the cost and may flood the EU market with cheaper products. Indeed, there is an ongoing investigation from the European Commission for potentially illegal subsidisation of battery electric vehicles value chains in China,[344] since this could put undue competitive pressure on European battery producers.

According to analysts at the multinational investment bank UBS, **one reason for the surge of Chinese battery manufacturers in Europe is due to mismatches in supply and demand in the short term**: while most EU cell manufacturers are still at a nascent stage, other players such as Korea are not expanding investment in the European market, as they see the subsidies provided by the IRA as the more attractive option. Unable to meet increased demand in battery production, the only player left that could fill these gaps in demand in the European market is China.[345]

Source: Desk research and interviews with EU institution policy officers.

Despite these vulnerabilities affecting the entire battery value chain and the significant economies of scale required for battery manufacturing, SMEs can still play an important role in the sector. **An area in which SMEs could thrive is niche and tailor-made solutions** with very high technological value to larger cell manufacturers, according to an interviewee. Gigafactories, in fact, are very complex systems that require the supply of not only battery components but also machinery and software management systems for batteries (e.g., to test the life, health status, and behaviour of batteries). The difficulties in scaling production could

---

[340] Federal Register. (2023). *Section 45X Advanced Manufacturing Production Credit*. Available at: https://www.federalregister.gov/documents/2023/12/15/2023-27498/section-45x-advanced-manufacturing-production-credit.

[341] Reuters. (2023). Battery start-up Freyr accelerates U.S. plans on IRA support. Available at: https://www.reuters.com/technology/battery-start-up-freyr-accelerates-us-plans-ira-support-2023-03-01/.

[342] BusinessKorea. (2023). Chinese Battery Makers Turning Tables on Korean Competitors in EU Battery Market. Available at: https://www.businesskorea.co.kr/news/articleView.html?idxno=204581.

[343] Bloomberg. (2023). Hungary Sees EV Investment Surge as BYD Poised to Set Up Factory. Available at: https://www.bloomberg.com/news/articles/2023-11-06/hungary-sees-ev-investment-surge-as-byd-poised-to-set-up-factory.

[344] European Commission. (2023). Commission launches investigation on subsidised electric cars from China. Available at: https://ec.europa.eu/commission/presscorner/detail/en/ip_23_4752.

[345] Financial Times. (2023). Europe over-reliant on Chinese EV batteries, warns South Korea's SK On. Available at: https://www.ft.com/content/1bfa3e86-c3b8-4fec-a383-0bceb8dbc820.

become an opportunity for SMEs, which could specialise in pilot production lines for small-scale manufacturing of battery cells for testing and validation purposes (see Box 20). At the same time, however, niche specialisation could represent a barrier to growth, as equipment manufacturers would be relegated to a role of specialised engineering companies.[346]

Box 20: Examples of battery pilot test line SMEs

Some SMEs may specialise in pilot production lines for small-scale manufacturing and testing before scaling-up operations take place. These companies may also come from outside the mobility ecosystem. Two examples are mentioned below.

Precision Roll Solution is an American company that offers an in-house pilot line test centre for product development of embossing patterns for plastic, non-woven, paper, thin gauge metals, composite products, and other substrates.[347] These products could also be tested for EV batteries, specifically for battery electrode and separator film production.

MSE Supplies is also an American company with a pilot production line designed for small-scale manufacturing, usually 300-500 battery cells per day. The equipment can be tested, validated, and subsequently customised according to the electrode materials, electrolytes, and cell configurations.[348]

Source: Authors' elaboration.

SMEs are also likely to play a crucial role in battery recycling. SMEs are often the first point of contact for xEV owners when batteries need a repair or a replacement. With end-of-life batteries of xEVs being forecast to increase almost twenty-fold between 2022 and 2030, SMEs will be heavily involved in the process of material retrieval and recycling.[349] According to an interviewee, SMEs could be specifically involved in mechanical recycling (e.g. disassembly system for battery packs), rather than metallurgical recycling (i.e. recovery of metals from batteries), which is machinery-intensive and requires significant upfront investment.

More generally, and within the automotive ecosystem, developments in markets for **electric vehicles** are of paramount importance for the transition of the mobility ecosystem to a low-emission sector. For instance, the Transition Pathway for the EU mobility industrial ecosystem report identified, through a co-creation process with industry stakeholders and experts, an important vulnerability involving automotive suppliers when it comes to the green transition.[350] Tier-1 suppliers are mostly multinational corporations and are better positioned, resource-wise, to transition away from legacy technologies. However, **tier-2 and tier-3 suppliers (which are mostly SMEs) are more at risk**: not only do they have fewer capacities to shift resources towards newer, more expensive green technologies like batteries, but they also rely on tier-1 suppliers, meaning that if the latter do not shift their production chain, tier-2 and tier-3 suppliers will have no customers to turn to. According to an interviewee, the Transition Pathways platform was meant to get stakeholders – and especially SMEs – to start taking actionable steps by widening their production scope. For instance, some SMEs working in the automotive sector could look into producing parts for small wind turbines, solar panels, pipes for hydropower, and parts for chemical manufacturing of batteries.

---

[346] Porsche Consulting. (2024). *Battery Manufacturing 2030: Collaborating at Warp Speed.* Available at: https://www.porsche-consulting.com/international/en/publication/battery-manufacturing-2030.
[347] See: https://www.precisionrollsolutions.com/products/pilot-line-testing.
[348] See: https://www.msesupplies.com/pages/cylindrical-cell-pilot-line.
[349] Bax&Company. (2022). Is there life after death for Europe's lithium-ion batteries?. Available at: https://baxcompany.com/insights/is-there-life-after-death-for-europes-lithium-ion-batteries/.
[350] European Commission. (2023). *Transition Pathways for the EU mobility industrial ecosystem.*

However, according to an interviewee, this diversification is not always easy on account of at least three elements:

- The supply chain in automotive is global. **Localising jobs and production is sometimes just not feasible**. It could also send a worrying message to non-EU partners that the EU might be closing for business. This could become a deterrent for foreign direct investment in Europe. It is, therefore, important to always keep in mind the 'open' component of strategic autonomy, whereby strategic dependencies are reduced to an acceptable level without the need for fully reshoring or localising jobs and production.
- **Diversification of production is costly,** and the automotive industry is particularly capital-intensive. Even mid-cap firms might not have high enough profit margins to diversify. A shift towards electrification might lead to sub-optimal economies of scope whereby the green transition would generate a situation in which a company might need to have the necessary capital to keep two businesses afloat: the legacy technology part (i.e. components for internal combustion engines), which are needed to generate the profits necessary for the company to generate the new expertise, and the new business the company is striving for (i.e. components for battery systems). This predicament is particularly risky for SMEs, as they are likely to be in the volume business and produce as much as possible. A sudden transition to new technologies may not only prove difficult for SMEs, resource-wise, but it may also alter their operational processes, requiring profound behavioural changes.
- **Electric vehicles require different skill sets and capacities, including compliance with high safety standards, which companies are required to be certified for**. Hence, changing the company's expertise focus takes away time and resources from current production operations.

6.1.2 OSA goals and overview of relevant policy initiatives

Given the vulnerabilities highlighted in the previous section, the EU set out five goals:

- Initiating **investment to enhance the EU's refining capabilities** for lithium, nickel, and graphite will reduce the risks for companies downstream. In particular, investment in ongoing projects involves actions for sustainable processing and refining of battery raw materials and for technologies for sustainable, cost-efficient, low-carbon footprint downstream processing.[351] The idea behind sustainable processing and refining is not only to have a smaller impact on the environment but also to become less reliant on other countries' refining capabilities.
- **Diversifying the supply of raw and processed materials** by securing trade agreements with other countries to reduce the supply risk of critical raw materials. An example is the recent free trade agreement with Chile, which foresees greater access to Chilean lithium from European companies.[352]
- **Bolstering the internal production capacity for cell manufacturing**. The objective is to achieve almost 90% of the Union's annual battery demand being met by EU battery manufacturers, translating to a capacity of at least 550 GWh in 2030.[353]

---

[351] See: https://bepassociation.eu/wp-content/uploads/2024/03/BATT4EU_SRIA-Webinar.pdf.

[352] European Commission. (2022). EU and Chile strengthen a comprehensive political and trade partnership. Available at: https://ec.europa.eu/commission/presscorner/detail/en/ip_22_7569.

[353] European Commission. (2023). *COM(2023) 161 final – Proposal for a regulation of the European Parliament and of the Council on establishin a framework of measures for strengthening Europe's net-zero technology products manufacturing ecosystem (NET Zero Industry Act)*, p. 22.

- **Stimulating circularity in the value chain** by collecting, reusing and recycling raw materials to a high degree throughout Europe. The 2023 Regulation on batteries and waste batteries will serve exactly this goal by setting eco-design standards for recycling of materials from waste batteries and introducing mandatory minima of recycled materials content in new batteries. In particular, the regulation sets a target for lithium **recovery from waste batteries** of 50% by the end of 2027 and 80% by the end of 2031, provides for **mandatory minimum levels of recycled content** (16% for cobalt, 85% for lead, 6% for lithium and 6% for nickel), and sets **recycling efficiency targets** for nickel-cadmium batteries is set at 80% by the end of 2025 and 50% by the end 2025 for other waste batteries.[354]
- **Investing in alternatives to replace the current li-ion technology** with less materials-intensive batteries. This includes solid-state and metal-air battery technologies, although these are still in the research phase.[355]

The first steps to achieve this goal were taken in 2017, when the EU launched, together with several stakeholders (Member States, industry, scientific community), the **European Battery Alliance** (EBA).[356] The goal was to ensure that the battery value chain could enhance the competitiveness of the automotive sector by being centre-stage in the transition to a low-carbon industry.

In 2018, the Commission launched the Strategic action plan on batteries with the aim of making Europe a global leader in sustainable battery production and use in the context of the circular economy.[357] This plan outlines targeted measures at the EU level along the battery value chain but does not yet mention OSA or SMEs.

Such initiatives are aimed at achieving the goals set out in the Net Zero Industry Act, which seeks to scale up the manufacturing of clean technologies in the EU, and the Transition Pathway, a soft policy tool for co-creation with the industry to engage companies and push them to diversify in the direction of new and clean technologies. With the Route 35 platform, the Commission also recently engaged with the automotive industry to monitor key performance indicators in five areas: charging infrastructure, electricity generation, raw materials access, skilled jobs (see Box 21 below) and affordability.[358]

Box 21: Securing a skilled workforce in the battery value chain

According to Commissioner Maroš Šefčovič, the EU is still lacking skilled workers in the sector.[359] Gigafactories require 90-100 skilled workers for each gigawatt-hour created. Hence, the ambition to produce 1TWh in 2025 would require around **800,000 skilled workers**.[360] To this end, EBA is working together with the InnoEnergy Skills Institute to develop training courses and methods for the immediate roll out of high-quality training

[354] Council of the EU. (2023). Council adopts new regulation on batteries and waste batteries. Available at: https://www.consilium.europa.eu/en/press/press-releases/2023/07/10/council-adopts-new-regulation-on-batteries-and-waste-batteries/.

[355] Itani, K. And De Bernandinis, A. (2023). Review on New-Generation Batteries Technologies: Trends and Future Directions. *Energies*, *16*(22), 7530.

[356] See https://www.eba250.com/.

[357] European Commission. (2018). *COM(2018) 293 final – Annex to the Communication from the Commission to the European Parliament, the Counil, the European Economic and Social Committee and the Committee of the regions – Europe on the move, Sustainable Mobility for Europe: safe, connected and clean.*

[358] European Commission. (2022). Launch of the Route 35 platform | Our priorities for achieving our electrification goals | Speech by Commissioner Thierry Breton. Available at: https://ec.europa.eu/commission/presscorner/detail/en/SPEECH_22_7785.

[359] European Commission. (2023). 7th High-Level Meeting of the European Battery Alliance: main takeaways by the Chair Maroš Šefčovič and the Council Presidency. Available at: https://single-market-economy.ec.europa.eu/document/download/290e0dac-ce60-4dfe-80b6-1fe0ec49162d_en?filename=Main%20takeaways_7th%20High-Level%20Meeting%20of%20EBA.pdf.

[360] European Commission. (2023). ESF+ powers skills for the battery industry. Available at: https://european-social-fund-plus.ec.europa.eu/en/news/esf-powers-skills-battery-industry.

across member states. Examples include Albatts[361], Drives[362] and the Automotive Skills Alliance.[363]

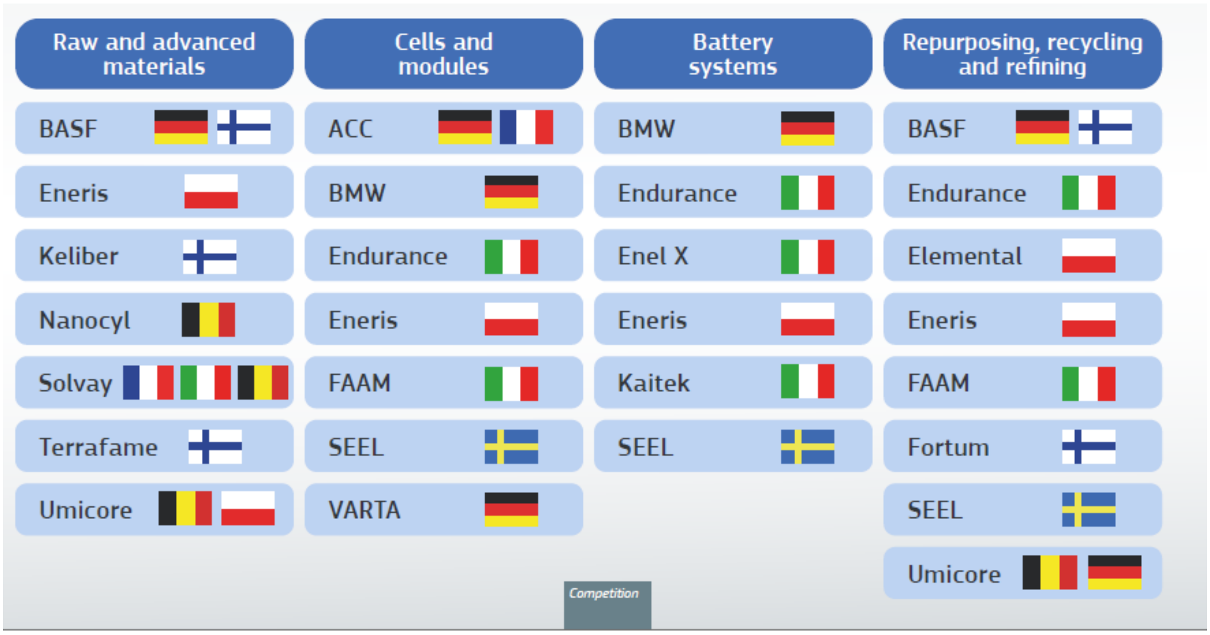
Mobility programmes, in particular, could be helpful on multiple counts, according to an interviewee: they can foster the exchange of best practices; they can help workers obtain the different skillsets required for the transition; they can help businesses understand how value creation is going to change – whether there will be a stronger focus on the mechanical side, the chemical side, or the digital end.

Source: Authors.

However, these tools and strategies will not be particularly useful without the right level of funding, according to interviewees. Hence, concrete action through financial support was needed. The main funding measures adopted by the European Commission that directly involve SMEs are two **IPCEIs (Important Projects of Common European Interest) for the battery value chain**, in 2019 and 2021 respectively. These IPCEIs aim to fulfil two of the OSA objectives set out in the Spanish Presidency document: bolstering internal production capacity and fostering circularity in the battery value chain.

The first IPCEI, approved in December 2019, involves 17 companies (two of which are SMEs – Keliber and Nanocyl) from seven Member States (Belgium, Finland, France, Germany, Italy, Poland and Sweden), which will provide up to EUR 3.2 billion in funding, unlocking an additional EUR 5 billion in private investment (Figure 25).[364]

Figure 25. Companies participating in the first IPCEI on batteries



Source: European Commission.[365]

The second IPCEI, called European Battery Innovation (EuBatIn), was approved in January 2021. It involves 42 companies (and 8 SMEs) from 12 Member States (Austria, Belgium,

[361] See https://www.project-albatts.eu/en/home.

[362] See https://www.project-drives.eu/en/home.

[363] See https://automotive-skills-alliance.eu/.

[364] European Commission. (2019). State aid: Commission approves €3.2 billion public support by seven Member States for a pan-European research and innovation project in all segments of the battery value chain. Available at: https://ec.europa.eu/commission/presscorner/detail/en/ip_19_6705.

[365] See: https://ec.europa.eu/commission/presscorner/detail/en/ip_19_6705.

Croatia, Finland, France, Germany, Greece, Italy, Poland, Slovakia, Spain and Sweden). The Member States will provide up to EUR 2.9 billion in funding, which is expected to unlock an additional EUR 8.8 billion in private investment (Figure 26).[366]

Figure 26. Companies participating in the second IPCEI on batteries

Source: European Commission.[367]

Both **IPCEIs foresee the participation of SMEs and start-ups**, as well as several collaborations with external partners such as universities, research organisations and other SMEs. SMEs are involved in a variety of areas, ranging from access to facilities for testing to knowledge-sharing for the development of advanced materials, and from supply of products for production in gigafactories to involvement in pilot lines for R&D&I to mention a few. A more

---

366 European Commission. (2021). State aid: Commission approves €2.9 billion public support by twelve Member States for a second pan-European research and innovation project along the entire battery value chain. Available at: https://ec.europa.eu/commission/presscorner/detail/en/IP_21_226.

367 See: https://ec.europa.eu/commission/presscorner/detail/en/IP_21_226.

detailed list is included in Table 7 below, while an example of spillovers from flagship investment into local supply chains involving the development of a Tesla gigafactory in Germany is presented in Box 22.

Table 7. SME involvement in IPCEIs on batteries

Company	Country	Position in the value chain	SME involvement
First IPCEI on batteries[368]			
ACC	France	Cells and modules	Allow SMEs from different Member States to conduct development within its premises at fair site costs. It will further open its testing lines to SMEs in neighbouring fields of activity.
Solvay	Italy	Raw and advanced materials	SMEs developing new materials will be granted open access to the Solvay units.
Second IPCEI on batteries[369]			
Solvay	Italy	Raw and advanced materials	Access to the testing lines, enabling SMEs to develop new product applications and designs in order to acquire specific skills and know-how.
Arkema	France	Raw and advanced materials	Open its infrastructures to third parties (including SMEs).
FCA (Stellantis)	Italy	Battery systems	Individual projects in collaboration with SMEs and academic institutions.
Prayon	Belgium	Raw and advanced materials	Share its pilot lines for R&D&I with SMEs beyond the partners included in the Project.
Rimac Automobili	Croatia	Battery systems	Allow access to its start-up incubator in areas related to battery systems and its applications in xEVs.
SUNLIGHT	Greece	Battery systems	SMEs will supply materials and components for the production improvement for battery cells and other battery system technologies.

Source: authors' elaboration based on State aid documentation.

Although most of the funding in these IPCEIs is directed towards large firms, this is unavoidable due to the level of scale needed to drive down battery production costs, according to an interviewee. Another interviewee confirmed by suggesting that **IPCEIs may not be best suited for SMEs** due to the sheer size of documentation needed to keep track of. Moreover, the objectives set out in the IPCEI can seldom be achieved by SMEs alone. At the same time, IPCEIs are useful in reducing market risks and can positively influence investment decisions. In particular, the same interviewee noted that **SMEs were heavily involved in constructing a recycling plant, acting as subcontractors or suppliers in all project areas** (see also Box 16). Geographical proximity was not an issue either, as many SMEs acted as consultants and could carry out their activities online – which made transnational collaboration easier.

[368] European Commission. (2019). *C(2019) 8823 final – Important Project of Common European Interest (IPCEI) on Batteries.* Available at: https://ec.europa.eu/competition/state_aid/cases1/202230/SA_54794_50781182-0000-C266-8373-C59CF8C4E8CE_311_1.pdf.

[369] European Commission. (2021). *C(2021) 494 final – Important Project of Common European Interest on European Battery Innovation (EuBatIn).* Available at: https://ec.europa.eu/competition/state_aid/cases1/202347/SA_55831_4052ED8B-0200-C756-9902-6A9A7F1BBA74_688_1.pdf.

Box 22: Example of spillovers of flagship investments into the local supply chain – the case of Tesla in Grünheide (Berlin-Brandenburg metropolitan area)

As part of the second IPCEI on batteries, Tesla was to receive EUR 1.1 billion in aid from the German federal government for its gigafactory in Grünheide, in the Berlin-Brandenburg metropolitan area. The aid was subsequently withdrawn, as per Tesla's request,[370] but the project was still carried out. The reason behind Germany's choice was the country's attractiveness as an automotive hub and its renowned engineering expertise. Additionally, Germany's central position in Europe and its strong automotive industry made it an ideal choice for Tesla to establish a manufacturing facility to cater to the European market.[371]

Indeed, Berlin-Brandenburg is also host to several other projects in e-mobility, including: BASF for cathode production and battery recycling; Rock Tech Lithium for lithium production; Microvast for LIB manufacturing; Mercedes, BMW, Daimler and Rolls-Royce for electric and drive technologies; and DESAF for autonomous driving tests, among others, as well as several R&D sites.

The Grünheide plant comprises several operating units in which the main components are manufactured, and the final assembly of the vehicle is carried out on-site. Most importantly, the **energy requirement for production should be covered as far as possible from locally and regionally produced renewable energy**.

Finally, the construction of the gigafactory also unlocked further **investment in infrastructure**, such as the extension of the state road to build a junction in Freienbrink Nord,[372] as well as the development of a new rail connection at the Fangschleuse station.[373]

Hence, thanks to the already-existing e-mobility ecosystem, requirements for locally sourced renewable energy and the development of further transport infrastructure, this investment will have positive spillovers in several different local supply chains.

However, it is not unlikely that such mega-projects will have undesirable consequences for **the local community**. In particular, the construction of the gigafactory required the destruction of almost 200ha of pine forest, though Tesla is legally obliged to relevel cleared forests on a 1:1 basis. Still, local climate justice groups occupied the surrounding remaining forest in protest against the expansion plans for the gigafactory, suggesting that local communities would prefer fewer cars.[374]

Source: Land Brandenburg[375] and IPCEI-batteries.[376]

[370] Reuters. (2021). Tesla decides against state aid for Germany battery plant as Musk opposes subsidies. 2021. Available at: https://www.reuters.com/business/autos-transportation/tesla-withdrew-state-funding-application-german-battery-plant-economy-ministry-2021-11-26/.

[371] Automotive News Europe. (2019). Why Tesla chose Germany for its new plant. Available at: https://europe.autonews.com/automakers/why-tesla-chose-germany-its-new-plant.

[372] Die Autobahn. (2022). A 10 Neubau Anschlussstelle Freienbrink-Nord. Available at: https://www.autobahn.de/die-autobahn/projekte/detail/a-10-anschlussstelle-freienbrink-nord.

[373] Trains. (2023). Tesla buys German railway line, now hosting passenger trains. Available at: https://www.trains.com/trn/news-reviews/news-wire/tesla-buys-german-railway-line-plans-passenger-trains-2/.

[374] ECEE. (2024). Tesla EV gigafactory drives Germany's latest climate justice struggle. Available at: https://www.eceee.org/all-news/news/tesla-ev-gigafactory-drives-germanys-latest-climate-justice-struggl/.

[375] Land Brandenburg. (2022). Häufig gestellte Fragen zur Tesla-Ansiedlung. Available at: https://www.brandenburg.de/cms/detail.php/bb1.c.658136.de.

[376] IPCEI-batteries. (2022). The importance of regional value creation structures in the battery industry. Available at: https://www.ipcei-batteries.eu/fileadmin/Images/accompanying-research/publications/2022-10-BZF_Clusterstudie_ENG_final.pdf.

The BATT4EU public-private partnership established in 2021 also earmarked up to EUR 925 in Horizon Europe for research on batteries, partially under the IPCEI umbrella.[377] The partnership includes 225 members, around 15% of which are SMEs. Such public-private partnerships could work as collaboration clusters in which SMEs could better coordinate their business plans. An example from South Korea is presented in Box 23. In Europe, such clusters could be "local for local alliances", where the larger EU cell manufacturers would be incentivised to buy equipment from local companies **to foster agreements with local suppliers**.[378]

Box 23: Best practices: collaboration clusters in South Korea's mobility sector

One way of ensuring a more effective approach to public funding is for private companies, research institutions and public authorities to work in clusters. This is particularly important for those smaller companies that are still working on legacy technology and which will be required to transition to more battery-focused production. As suppliers, they do not have full control of their business plans because they depend on OEMs as customers, but if OEMs are shifting their production, so must the suppliers. However, the smaller the company is, the more difficult it becomes to start a transition project and access the funding. The idea, then, is to have a **project coordinated by the larger companies when public funding is available, which will also help SMEs access this money**.

An example comes from South Korea's KICOX,[379] which employs the so-called **cluster policies**, whereby specialised industries operate in "mini-clusters". Cluster policies do not focus on individual constituents but on the building of networks among them: these policies place more emphasis on fostering interconnected networks, networks created through collaborations between large companies and SMEs, joint research of SMEs and research institutes, and joint projects between SMEs.[380] The government also established centres to identify SMEs with growth potential and foster small but strong enterprises with technology innovation competencies.[381]

Each mini-cluster in South Korea specialises in particular areas that can harness the strength of R&I of cross-sectoral projects. For instance, the Jeonbuk cluster researches and produces auto and electric parts but also focuses on autonomous driving for commercial vehicles, eco-friendly vehicles, ship equipment, and lightweight material moulding. Likewise, the Chungcheong cluster produces mobility parts and materials and advances projects for hydrogen energy vehicle parts and renewable batteries.[382]

Europe also has a cluster policy in action,[383] and **in times of transition, where SME suppliers are strongly relying on OEMs to provide direction on greening and electrification, it is important to ensure continuous collaboration among stakeholders**. When such collaborative efforts are lacking, OEMs' decisions may have significant negative

[377] See https://bepassociation.eu/.

[378] Porsche Consulting. (2024). *Battery Manufacturing 2030: Collaborating at Warp Speed.* Available at: https://www.porsche-consulting.com/international/en/publication/battery-manufacturing-2030.

[379] See https://www.kicox.or.kr/index.do.

[380] KICOX. (2020). *The Industrial Complex Cluster Program of Korea*. Available at : https://clustercollaboration.eu/sites/default/files/international_cooperation/the_industrial_complex_cluster_program_of_korea_2010.compressed.pdf

[381] KICOX. (2015). *Industrial Complex Clusters in Korea: Achievements and Challenges.* Available at: https://www.kicox.or.kr/component/file/ND_fileDownload.do?q_fileSn=125829&q_fileId=1d1f8f35-ae46-4f9b-a452-6e22eabab2b3.

[382] For all, see: https://www.kicox.or.kr/index.do#.

[383] See: https://single-market-economy.ec.europa.eu/industry/strategy/cluster-policy_en.

spillovers on the local supply chain, as the example of Stellantis in Italy seems to exemplify.[384] Cases such as these may lead to question the effectiveness of cluster policies and the subsequent ability of tier-2 and tier-3 suppliers to follow the transition pathway for mobility.

Source: Authors' elaboration based on desk research and interview with business association representative

Another source of funding is represented by the **Innovation Fund**, which is financed through the revenues of the European Emission Trading System (ETS). The Fund aims to support flagship projects within Europe that can bring about significant emission reductions, and it is establishing a proven record of financing battery innovation.[385] According to the Fund's dashboard, of the eight projects undertaken since 2021 that are related to batteries (worth a total of EUR 354 million), 5 participants out of 14 are SMEs, receiving around EUR 194 million, or 55% of the total funding (see Table 8).[386] On 6th December 2023, the European Commission also announced a dedicated instrument for the battery value chain under the Innovation Fund, possibly amounting to EUR 3 billion over three years. However, it is unclear how SMEs will be involved.

Table 8. Battery-related projects financed through the Innovation Fund

Project name	Project description	Entry in operation	EU contribution (EUR)
Green Foil project	Low CO2 Footprint Battery Foil for Li-ion Battery Production for Energy Storage	01/02/2023	2,676,706
CarBatteryRe Factory	Assembly plant for serial production of industrial energy storage systems based on second-life car batteries and disruptive full-pack technology.	31/12/2023	4,499,400
ReLieVe	Recycling Li-ion Batteries for Electric Vehicles	01/04/2027	67,559,352
Listlawelbattco ol	Light and structural laser welded battery cooler	31/01/2027	3,651,974
Giga Arctic	Building a European future for clean batteries to accelerate the renewable energy transition	31/10/2028	100,000,000
DAWN	200MW Production of thin-film solar by Sweden	31/12/2025	32,265,535
ELAN	Upscaling Vianode innovative synthetic graphite production technology for a responsible electrification of Europe	30/06/2027	90,000,000

Source: authors' elaboration based on Innovation Fund dashboard.

Finally, the European Innovation Council, operating under the EU Horizon Europe programme with a total budget of EUR 10.1 billion, provides funding opportunities of up to EUR 2.5 million in grants and EUR 15 million in equity for carefully selected SMEs and start-ups developing cutting edge innovations.[387] For instance, in March 2022, Octave, a Belgian SME, received EUR 1.05 million in funding from the EIC to develop a cost-effective and reliable energy storage system with second-life batteries from electric vehicles, thus contributing to the OSA goal of fostering circularity.[388]

However, despite these success stories, **one important barrier remains the difficulty companies encounter in accessing funding**, especially regarding understanding information relevant to financing. To this end, in December 2023, the Commission's Executive

---

[384] Il Post. (2024). Stellantis sta lasciando nei guai decine di aziende. Available at: https://www.ilpost.it/2024/04/10/stellantis-crisi-fornitori-torino/.

[385] European Commission. (2024). What is the Innovation Fund?. Available at: https://climate.ec.europa.eu/eu-action/eu-funding-climate-action/innovation-fund/what-innovation-fund_en.

[386] Innovation Fund Dashboard. (2024). Portfolio of signed projects. Available at: https://dashboard.tech.ec.europa.eu/qs_digit_dashboard_mt/public/sense/app/6e4815c8-1f4c-4664-b9ca-8454f77d758d/sheet/bac47ac8-b5c7-4cd1-87ad-9f8d6d238eae/state/analysis.

[387] See https://eic.ec.europa.eu/eic-funding-opportunities_en.

[388] NCP Brussels. (2022). Brussels company awarded in most competitive EIC Accelerator funding programme. Available at: https://ncp.brussels/brussels-company-awarded-in-most-competitive-eic-accelerator-funding-programme/.

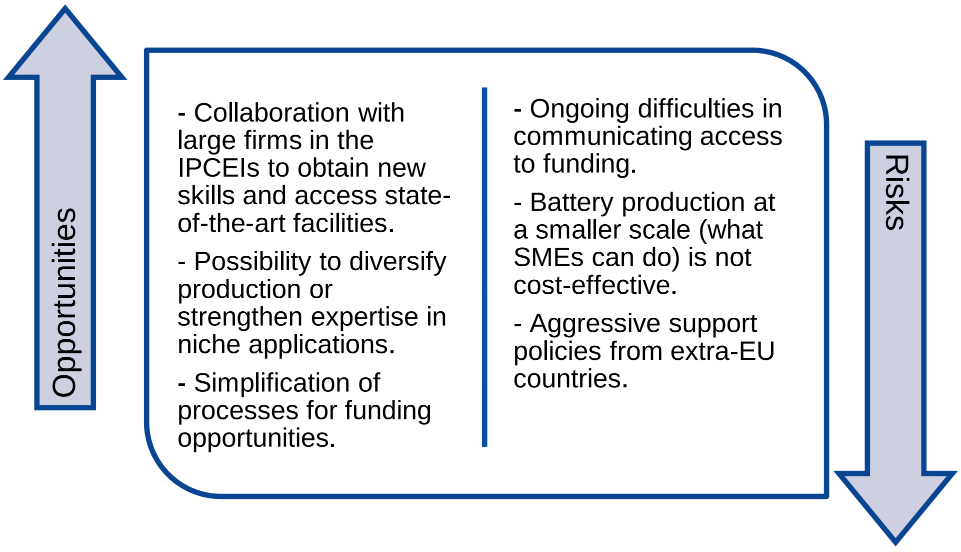
Vice-President Šefčovič announced a new pilot initiative to provide a **one-stop shop service for guidance to SMEs in the battery industry to access EU finance**.[389] The initiative has three main objectives:

1. **Facilitate SME applications for EU funds** by reducing the time and resources spent on applications;
2. **Strengthen industrial value chains** to address financing gaps in the battery value chain both upstream and for end-of-cycle activities;
3. **Aid efficient deployment of EU funds** to ensure recognition of the most promising greenfield projects.

Beyond these European-level measures, **some national initiatives exist to expand domestic capacity for batteries**. In **Finland**, the Battery Strategy 2025 outlines the measures that can help the country become an internationally important actor in the battery and electrification sector. Measures include the promotion of the battery value chain in industrial policy; the development of skills in the sector; the strengthening of international contacts by getting representatives of the Finnish battery sector at the relevant EU tables; the development of an environment conducive to investments; the promotion of sustainable and responsible battery production; the promotion of the brand and communications about the sector; and the development of agile funding for high-risk and long-term investment projects.[390] Though this strategy is not aimed specifically at SMEs, the holistic approach will necessarily involve them, either as part of direct production or as support to production activities.

A summary of the risks and opportunities for SMEs involved in the battery value chain in terms of achieving higher strategic autonomy is presented in Figure 27.

Figure 27. Opportunities and risks for SMEs from higher strategic autonomy in the battery value chain



[389] EBA250. (2023). Executive Vice-President of the European Commission Maroš Šefčovič announces new cooperation with EIT InnoEnergy to facilitate access to EU public finance for battery start-ups. Available at: https://www.eba250.com/executive-vice-president-of-the-european-commission-maros-sefcovic-announces-new-cooperation-with-eit-innoenergy-to-facilitate-access-to-eu-public-finance-for-battery-start-ups/.

[390] Ministry of Economic Affairs and Employment of Finland. (2021). *National Battery Strategy 2025*. Available at: https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/162685/TEM_2021_6.pdf?sequence=1&isAllowed=y.

6.1.3 Recommendations for future policy actions

Following the above analysis of the battery value chain, its vulnerabilities, opportunities and risks, and ongoing measures and projects, the following recommendations can be made:

- **Make mechanisms for implementing SME funding more efficient.** Making funding quick, predictable and easy to access is key to competitiveness, especially for frontrunners in the green transition. The one-stop-shop service for SME funding from EU institutions is a good starting point, but it should also incorporate Member State funding initiatives to avoid information fragmentation. This would allow European SMEs to become acquainted with what type of funding is available across Member States through this simple one-stop-shop – and possibly, asses together with EBA if SMEs could tap into cross-state funding. This will minimise the risk of disparities in funding access between SMEs from larger and wealthier countries and the rest.
- **Ensure that public funding is easily available to mid-cap firms**. Especially in the automotive sector, where several suppliers will be required to shift their production focus to support electro-mobility, mid-caps will play a key role as enablers of this transition, connecting OEMs with tier-2 suppliers. They will be the main point of contact with OEMs for the key components of xEVs (battery packs); likewise, several tier-2 suppliers will rely on the business strategies of these mid-caps. However, opportunities for mid-cap firms to access funding are limited, and it is important to ensure that mid-cap firms involved in this transition are able to access the required funding opportunities. The European Investment Bank (EIB), for instance, has financed several projects in mobility (most recently, the acquisition of 15 electric rolling stock units in Lithuania),[391] and may prove an important source of funding for companies and local communities seeking to pursue the green transition in mobility.
- **Provide confidence to private investors to support SMEs in the sector**. Private investors are less willing to invest in Europe because of the energy crisis, the IRA, and the disruptions in the supply chains from China. Public financing, such as the IPCEIs, provides de-risking in the form of support from public authorities with the aim of unblocking additional private funding. However, in order to do so effectively, public financing initiatives should transmit confidence to private investors. They can do so in two ways:
    - First, crowd-in from private investors could take place in the SME Growth Markets – a multilateral trading facility to improve access to market-based financing thanks to reduced administrative and cost burdens for SMEs. This will boost SMEs' standing on access to finance by reducing dependence on bank funding, diversifying investors, and allowing easier access to additional equity capital and debt financing, as well as higher public profile and brand recognition. Listing on the SME Growth Markets is also likely to increase the attractiveness of market-based funding if successful SMEs can more easily graduate to the main markets.[392] The experience with market-based financing SMEs accumulate on these dedicated markets, may also prove useful as fast-growing SMEs transition into mid-cap firms (i.e. those with 500-3,000 employees), since many public funding options are only available to SMEs.[393] In particular,

[391] See: https://www.eib.org/en/projects/all/20210509.

[392] European Commission. (2018). *SWD(2018) 243 final – Impact Assessment accompanying the document "Proposal for a regulation of the European Parliament and of the Council amending Regulations (EU) No 596/2014 and (EU) 2017/1129 as regards the promotion of the use of SME growth markets"*, p. 54.

[393] EIB. (2024). *Hidden champions, missed opportunities – Mid-caps' crucial roles in Europe's economic transition*. Available at: https://www.eib.org/attachments/lucalli/20230277_hidden_champions_missed_opportunities_en.pdf.

collaboration with the EIB might prove essential. To date, the EIB is involved in several different equity funds for SMEs and mid-caps, but none of them involve mobility or are addressed to European companies.[394]

- Second, public authorities should clearly state that the EU is here for the long run, that the desire is to become champions in the energy and digital transition, and that to maintain global competitiveness, investment is required now, as demonstrated by the significant shares that Chinese companies are gaining on the European battery market. Although European champions are most likely to be large and mid-cap firms,[395] SMEs can play an important support role, as described in this chapter.

- **Become more engaged with SMEs at the local level.** The flow of information from EU-level associations and alliances down to the specific SMEs is uncertain. Individual SMEs often do not have the capacity or resources to engage with EU-level business associations and alliances. Hence, local authorities and collaboration clusters could work as liaising points between the supranational and regional levels – not only do local authorities know the economic reality of the regions they oversee better than the EU-level associations, but they are also easier access points for SMEs. Engagement could also take a more hard-policy approach, whereby policy-makers could incentivise the larger battery manufacturers to purchase equipment and enter into commercial agreements with local suppliers. Such an approach could be particularly relevant to boost cluster policies in the battery and automotive ecosystem, especially in cases where the local supply chain is experiencing a crisis period.

- **Provide SMEs with a plan to diversify by leveraging niche applications.** The transition towards xEVs, which have far fewer moving parts compared with traditional internal combustion engines, may put the supply chain at risk. European and national legislators could promote and share with SMEs best practices about how automotive SMEs can expand into new areas by diversifying production and not be left behind by holding onto legacy technologies. SMEs in mobility could also shift towards niche applications or supply machinery to other companies involved in battery production. An example comes from the paper manufacturing industry, which provides a case of good practices for cross-sectoral synergies. Delfort, an Austrian company specialised in paper manufacturing for several products, has also taken on producing the paper sheets required for battery separators (insulating components that prevent direct contact between the positive and negative electrons within the battery cell). SMEs in automotive could apply a similar strategy by looking at other markets that could help them re-purpose their machinery and operational processes with minimal changes and leverage their know-how in manufacturing particular components with potential for application in other fields (e.g. robotics, electric appliances, textiles, etc.).

- **Decrease the burden of compliance with the battery regulation for SMEs.** The battery and waste battery regulation currently has a lot of requirements (see Section 6.1.2), which may be difficult for SMEs to keep track of. Some public efforts could be put into assisting companies to ensure that their products are compliant with the Regulation, such as calculation of the carbon footprint and labelling requirements, while reducing the burden on SMEs.

[394] See: https://www.eib.org/en/products/equity/funds/.

[395] EIB. (2024). *Hidden champions, missed opportunities – Mid-caps' crucial roles in Europe's economic transition*. Available at: https://www.eib.org/attachments/lucalli/20230277_hidden_champions_missed_opportunities_en.pdf.

6.2 Fuel cells

6.2.1 Overview of the value chain, positioning of SMEs and strategic vulnerabilities

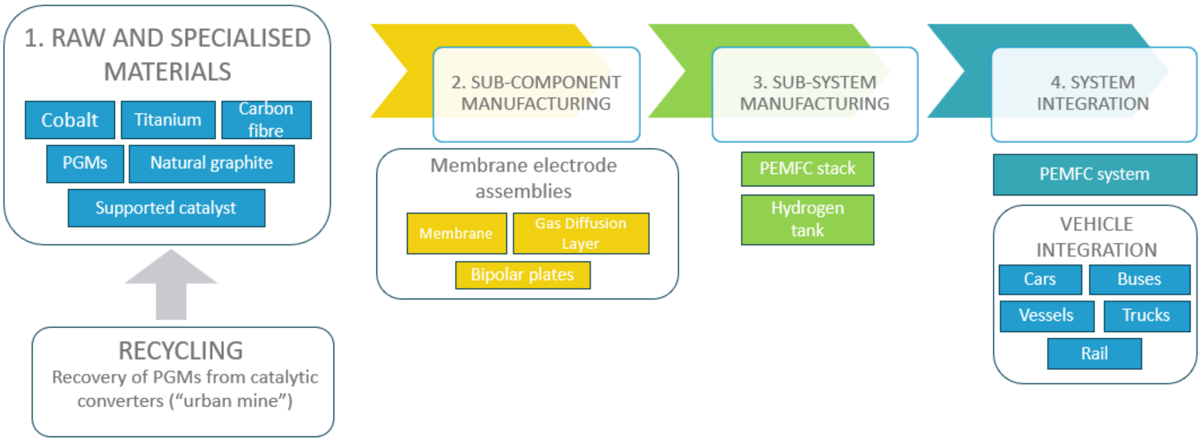
Fuel cells convert the chemical energy of reactants (hydrogen, air) into water and exhaust heat and are, therefore, another important technology to achieve decarbonisation. Fuel cells can be used for both stationary and transport purposes. Stationary fuel cells generate electricity through an electrochemical reaction, not combustion, providing clean, efficient, and reliable off-grid power to homes, businesses, telecommunications networks, utilities, and others.[396] In transportation, fuel cells can be used to power cars, buses, medium- and heavy-duty vehicles, as well as ships, aeroplanes, drones, and trains.[397]

There are three main reasons to pursue fuel cell technology in mobility, even if batteries represent the more commercially successful and cheaper solution:

- Fuel cell technologies are part of broader efforts from the EU and Member States to develop cleaner sources of energy, such as hydrogen, as a way to taper out fossil fuel usage (see also Chapter 9.3 on electrolysers).
- Fuel cell vehicles have longer autonomy and shorter refuelling times compared to battery electric vehicles, which makes them better alternatives for long haul, heavy-duty transport (e.g. trucks, maritime shipping) in the EU's efforts to decarbonise the transport industry.
- Although fuel cells require several critical raw materials (see further below), diversification in the requirements of raw materials for batteries and fuel cells (though there is certainly some overlap) can ease the burden on the battery value chain.

The value chain for fuel cells is very complex and is intertwined with that of hydrogen production and supply. However, for the purposes of this study, it can be divided into four key segments, as shown in Figure *28*:

Figure *28. Schematisation of the fuel cell value chain*



Source: Authors.
Note: PGMs is Platinum Group Metals; PEMFC is Proton Exchange Membrane Fuel Cell.
Vehicle integration does not connect directly to recycling because the latter mostly focuses on PGMs.

[396] See: https://www.fchea.org/stationary.
[397] See: https://www.fchea.org/transportation.

The market for fuel cells in Europe is still at a nascent stage. In 2020, only around 13,200 fuel cells were deployed for either stationary or transport use in Europe, for a total capacity of around 150 MW/unit.[398] Although this constitutes a significant increase compared with the previous years, the total capacity is still far behind the amount of energy generated in the battery value chain.[399] Moreover, according to interviewers, it is not currently possible to ask companies to produce GWh of energy as they lack the capacity to do so.

The market is, however, very dynamic at the moment, with technology readiness starting to mature and companies bringing their product to the market. As such, according to interviewees, **many SMEs are either merging or being acquired by larger companies to sustain market competition**. For example, SYMBIOFCell – a start-up created in 2010 in Grenoble, France – was acquired in 2018 by the tyre giant Michelin.[400] Foreign acquisitions are also commonplace: in 2020, the Belgian company Borit, which specialises in the manufacturing of metal bipolar plates, was acquired by the Chinese automotive manufacturer Weifu.[401]

However, interviewees are **cautious about introducing FDI screening measures** to prevent the acquisition of European SMEs from non-EU companies. Indeed, there are also examples of fruitful collaborations following foreign investment in European companies. For instance, the South Korean KSOE (Korean Shipbuilding & Offshore Engineering), a member of the Hyundai Group, is investing EUR 45 million in the Estonian SME Elcogen to further deepen the collaboration on emission-free power generation systems as well as green hydrogen production. KSOE's decision was motivated by the cutting-edge technology Elcogen offers, which is at the most advanced stages on the globe.[402] The investment would then help Elcogen gain access to new markets beyond the EU and acquire expertise from global leaders in the hydrogen technology industry.

In terms of mobility, fuel cell electric vehicles (FCEVs) are still not widely distributed for commercial use. In 2022, only 1,537 FCEVs were registered in Europe, bringing up the total fleet to around 5,570, with 83% being passenger cars.[403] FCEVs are also mostly concentrated in Germany, which can boast the best hydrogen refuelling infrastructure to date in Europe. According to the International Energy Agency (IEA), the global stock for FCEVs reached 72,100 in 2022, thanks to around 20,000 new registrations.[404] Hence, Europe accounts for slightly less than 8% of the total FCEVs, whereas Korea is home to over half of FCEVs, thanks to generous subsidies from the government – up to more than EUR 25,000 per purchased vehicle (see Box 24). Still, original equipment manufacturers (OEMs) seek to operate around 50,000 hydrogen-powered heavy-duty vehicles in Europe by 2030.[405] To this end, **several European countries have initiated subsidy schemes to encourage the uptake of FCEVs**. For instance, in Belgium, the Flemish Ecologiepremie+ scheme offers CAPEX (capital

---

[398] European Hydrogen Observatory. (2024). *The European hydrogen market landscape*. Available at: https://observatory.clean-hydrogen.europa.eu/sites/default/files/2024-02/Report%2001%20-%20The%20European%20hydrogen%20market%20landscape%20-%20February%20update.pdf.

[399] *Ibidem*
See: https://www.iea.org/data-and-statistics/charts/lithium-ion-battery-manufacturing-capacity-2022-2030.

[400] See: https://www.symbio.one/en/who-we-are/our-history.

[401] https://www.yicaiglobal.com/news/china-weifu-to-acquire-belgian-fuel-cell-parts-maker-borit- Ycai. (2020). China's Weifu to Acquire Belgian Fuel Cell Parts Maker Borit. Available at: https://www.yicaiglobal.com/news/china-weifu-to-acquire-belgian-fuel-cell-parts-maker-borit-.

[402] Elcogen. (2023). HD Hyundai makes a Strategic Investment in Elcogen. Available at: https://elcogen.com/hd-hyundai-makes-a-strategic-investment-in-elcogen/

[403] European Hydrogen Observatory. (2024). *The European hydrogen market landscape*. Available at: https://observatory.clean-hydrogen.europa.eu/sites/default/files/2024-02/Report%2001%20-%20The%20European%20hydrogen%20market%20landscape%20-%20February%20update.pdf.

[404] IEA. (2023). *Global EV Outlook 2023*. Available at: https://iea.blob.core.windows.net/assets/dacf14d2-eabc-498a-8263-9f97fd5dc327/GEVO2023.pdf.

[405] See: https://hydrogeneurope.eu/wp-content/uploads/2022/12/2022.12_HE-and-ACEA-letter-on-AFIR-ambitions-for-HDV-segment_fin-1e29c0a1bcb4b376e94d79b021f8c85e.pdf.

expenditure) support to companies who want to purchase fuel cell vehicles. Small enterprises receive 30% CAPEX support on purchases, and large enterprises 15%.[406]

Box 24: The generous subsidies to stimulate the fuel cell electric vehicle market in South Korea

In early 2023, the South Korean government unveiled a massive upgrade to its hydrogen vehicle subsidy programme, vastly increasing the number of FCEVs it is prepared to support (up to 16,000), with consumers able to purchase FCEVs for up to a halved price. This measure is part of the 2030 National Greenhouse Gas Reduction Target, up to a 40% reduction compared to 2018 levels – something that is very difficult to achieve without mass commercialisation of zero-emission vehicles. The government also revealed that 95% of the supported FCEVs will be passenger cars. This scheme would also help support the local automotive industry, with the Hyundai Nexo being one of the few commercially viable fuel cell electric cars to date.[407]

The total price tag of the updated scheme is yet to be revealed, but the car scheme alone could cost USD 300 million if all 16,000 units are sold with maximum subsidies.[408] This potential sum is much larger than what EU Member States are providing at the moment, which often amounts to a few thousand euros per vehicle, and where the total subsidy scheme often includes other xEV categories, such as BEVs and HPEVs.[409] However, this difference is not surprising, given the differences in the level of commercial readiness of FCEVs between Korea (e.g. with the Hyundai Nexo) and the EU Member States, where most FCEVs are at the first industrial deployment stage.

This move is part of a long-standing national strategy for the pursuit for FCEV development that, over the past 30 years, has seen the implementation of a series of national R&D programmes throughout many stages, from selection of technology, building infrastructure and legislations, demonstration, and subsidising mass-produced FCEVs.[410]

However, there is growing consensus that the opportunity for hydrogen FCEVs in the global passenger vehicle market is shrinking fast due to infrastructure constraints and high running costs relative to battery-electric equivalents.[411] Indeed, representatives of the South Korean industry pointed out that the government policies to expand hydrogen fuel cells have not met expectations, with only 200 MW per year generated, which is significantly lower than the industry's anticipated demand.[412]

Source: Authors' elaboration.

Because of the novelty of the technology and the lack of large-scale commercial applications, **SMEs appear to have good standing in the EU fuel cell market**. While there are no reliable estimates on the share of SMEs involved in fuel cell production, SMEs dominate the broader

[406] See: https://www.vlaio.be/nl/subsidies-financiering/ecologiepremie. For a list of all measures undertaken by European countries to incentives the uptake of hydrogen technologies, including fuel cell vehicles (cars, vans, buses, trucks, boats), see: https://observatory.clean-hydrogen.europa.eu/hydrogen-landscape/policies-and-standards/national-policy.

[407] Hydrogen Insight. (2023). South Korea's multi-million-dollar vehicle subsidy scheme could halve the price of new hydrogen cars. Available at: https://www.hydrogeninsight.com/transport/south-korea-s-multi-million-dollar-vehicle-subsidy-scheme-could-halve-the-price-of-new-hydrogen-cars/2-1-1397266.

[408] *Ibidem*

[409] See: https://observatory.clean-hydrogen.europa.eu/hydrogen-landscape/policies-and-standards/national-policy.

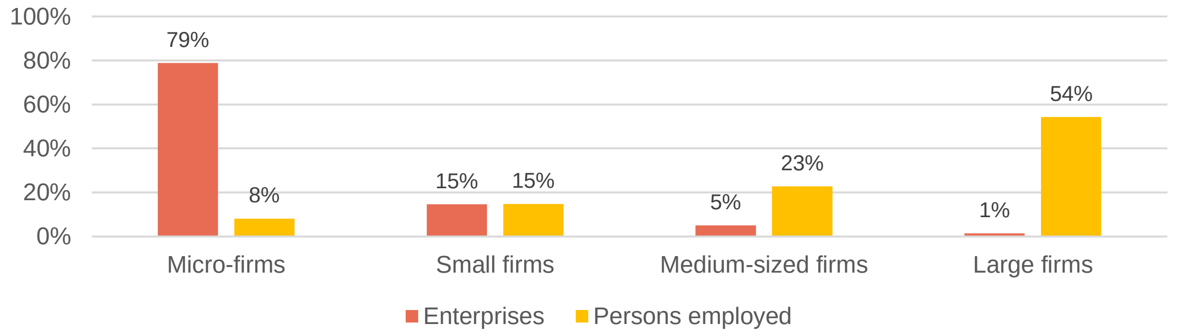
[410] Yoo, S., & Park, S. (2023). South Korea's national pursuit for fuel cell electric vehicle development: The role of government R&D programs over 30 years (1989–2021). *International Journal of Hydrogen Energy*, *48*(26), 9540-9550.

[411] Hydrogen Insight. (2023). South Korea's multi-million-dollar vehicle subsidy scheme could halve the price of new hydrogen cars. Available at: https://www.hydrogeninsight.com/transport/south-korea-s-multi-million-dollar-vehicle-subsidy-scheme-could-halve-the-price-of-new-hydrogen-cars/2-1-1397266.

[412] Fuel Cell Works. (2024). Korea Leads With Over 1GW in Fuel Cell Power Generation, Yet Faces Industry Challenges. Available at: https://fuelcellsworks.com/news/korea-leads-with-over-1gw-in-fuel-cell-power-generation-yet-faces-industry-challenges/.

sector of manufacturing of other electric equipment (NACE C27.9), which also includes fuel cell production, making up 99% of the firms involved and employing 46% of the persons (Figure 29).

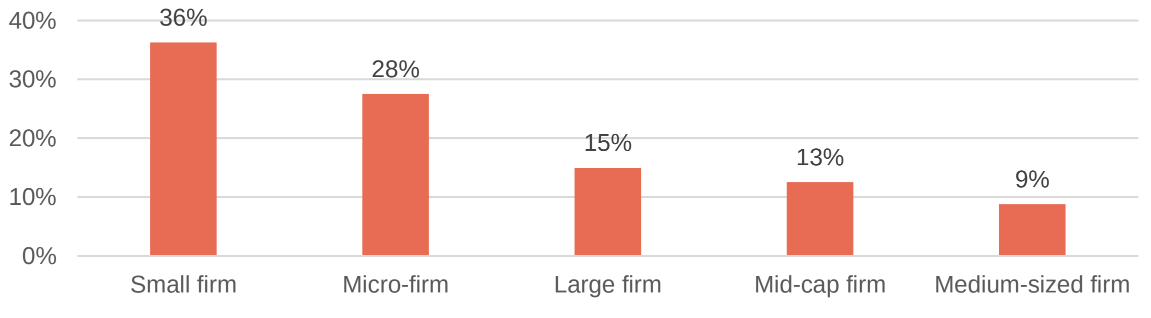
Figure 29. Firm breakdown in manufacturing of other electric equipment, including fuel cell production, in the EU-27, 2022



Source: Eurostat table sbs_sc_ovw
Note: Fuel cell production is part of NACE code C27.9 ("Manufacture of other electric equipment").

Due to the lack of reliable official estimates on the number and share of SMEs in fuel cell production, we employed the Milda company database to identify 80 fuel cell producers in the EU.[413] **Indeed, a closer look at companies active in fuel cell production (Figure 30) reveals that 72% of the companies are SMEs, while mid-caps and large firms account for 13% and 15% of the total, respectively.** These figures are also supported by interviewees who stated that the great majority of firms in the hydrogen value chain are SMEs. Some examples include PowerCell in Sweden and NedStack in the Netherlands. From a geographical standpoint, Milda data suggests that SMEs and mid-cap firms active in fuel cell technologies are mostly concentrated in Germany and, to a lesser extent, Italy and the Netherlands. Spain and France follow suit, while the presence in Eastern European countries is much sparser. A reason for this may be the strong focus on R&D and piloting activities in this technology, which have been present in these countries for a longer time compared to Eastern European Countries. However, as one interviewee noted, **the involvement of SMEs in the field will strongly depend on the market potential for this technology**, which remains unknown at such an early stage. Box 25 shares some best practices for market de-risking and garnering public support from the Zero-Emission Valley (ZEV) project in France.

Figure 30. Breakdown of firms active in fuel cell technology by size in Milda, in the EU-27, 2024



Source: Authors' elaboration from Milda.

[413] Please note that multiple technologies exist for fuel cells. The two main ones are proton exchange membrane fuel cell (PEMFC) and solid oxide fuel cell (SOFC). PEMFCs are those mostly used for FCEVs, whereas SOFCs are employed for stationary and maritime applications.

Note: SMEs include firms with up to 249 employees; mid-cap firms are between 250 and 999 employees; large firms anything beyond that. Subsidiaries are excluded.

Box 25: Best practices for commercial de-risking and public support – the case of the Zero Emission Valley project in France

The Zero Emission Valley (ZEV) project in Auvergne-Rhône-Alpes (France) aimed to deploy 1,200 fuel cell vehicles (FCEVs, more specifically company cars and commercial vans) in the region. The two main challenges they faced were the procurement of hydrogen refuelling stations for the FCEVs, and the commercial availability of light duty vehicles on the market.

To set up the commercial structure, the ZEV project launched a project company, HYmpulsion, consisting of several different shareholders – industry players, banks, and the local authorities. All these shareholders are committed to clear, transparent governance rules to ensure successful cooperation.

The ZEV project also involved the **procurement of 1,200 vehicles to create sufficient demand for the hydrogen refuelling stations**. Due to the lack of commercial vehicles available, the project actors also looked at the acquisition of additional heavy-duty vehicles (buses, trucks). **By first procuring the vehicles, they could show that the refuelling stations would be profitable in the future and that an expansion would be the right step.**

From the side of public support for the project, things were perhaps easier. The shareholders included actors from across the entire value chain (including start-ups and SMEs) located in the region. Moreover**,** the region is required to improve air quality, making the benefits of a large-scale FCEV project permanent.

The main lesson learned from the ZEV project is to work closely with the various industry clusters to ensure collaboration and engagement are high. Furthermore, providing the necessary vocational training would be essential to keep and create new jobs in the region, and deliver successful projects in the future, establishing Auvergne-Rhône-Alpes as a competitive pole in the sector. The ZEV project shows that at such an early market development stage, the setup of a hydrogen ecosystem must be orchestrated by all stakeholders together, especially the region, to be able to put the obtained public funding to efficient use.

Source: Clean Hydrogen Partnership.[414]

European fuel cell producers suffer from several of the same vulnerabilities as battery producers, particularly upstream. The EU mines less than 3% of the raw materials necessary for fuel cells, although it is able to produce around 18% of the processed or specialised materials.[415] Mining of platinum group metals (PGMs), which are critical to the functioning of hydrogen fuel cells,[416] represents only 0.5% of global primary production.[417] European companies are somewhat less vulnerable at the sub-component manufacturing stage, which is the least at risk of losing strategic autonomy, thanks to EU firms producing 25% of the global

[414] See: https://h2v.eu/analysis/best-practices/stakeholder-managementpublic-support.

[415] JRC. (2023). *Supply chain analysis and material demand forecast in strategic technologies and sectors in the EU – A foresight study*.

[416] IPA. (2023). Joint briefing note Platinum Group Metals (PGMs) - essential critical raw minerals for the hydrogen economy. Available at: https://ipa-news.com/assets/news-debates/Final_IEA%20ministerial%20note%20PGMs%2026%20Sept%202023.pdf.

[417] See: https://rmis.jrc.ec.europa.eu/rmp/Platinum-Group%20Metals

supply.[418] However, there is little vertical integration, which means that European firms, and especially SMEs, are most at risk of lacking competitiveness on the global stage. Finally, there is little involvement in system integration (only 12% of the global share), with this activity spread across a pool of companies, most of which are at an early commercialisation stage.[419] Recycling consists mostly of PGMs, which have exactly the same properties as when they are first mined. This means primary and secondary platinum are completely interchangeable and can be reused repeatedly in new stacks.[420]

Given the novelty of viable fuel cell technologies and the breadth of their applications, start-ups and SMEs can play several different roles. For instance, SMEs can:

- **Contribute to R&D operations** thanks to their agile nature and focus on innovation. Around 24% of unique participants in the 176 fuel cell EU-funded projects under the Horizon programmes are SMEs (200 out of 848 participants), which participate in projects accounting for around 25% of the EU net contribution for fuel cell-related projects (EUR 215 million out of EUR 866 million).[421] Two more fuel cell-related projects (HyPush and HyNCREASE) are also being funded through the Innovation Fund, for a total of EUR 8.3 million in order to achieve the goals set out in the NZIA.[422] According to interviewees, due to the novelty of the technology, larger companies often externalise R&D activities to SMEs in order to minimise risks and maintain profit margins. Examples include Convion in Finland and EKPO in Germany.
    - Convion is a spin-off of Wärtsilä, a company specialising in manufacturing and servicing of power sources and other equipment in the marine and energy markets. Convion was established in 2012 with the aim of developing and commercialising solid oxide fuel cell (SOFC) systems for distributed power generation.[423]
    - EKPO is a 30-strong joint venture between two automotive manufacturers: the German ErlingKlinger and the French Plastic Omnium. EKPO was established with the goal of accelerating the path to industrial mass production for PEMFCs in mobility.[424]
- **Provide services for pilot tests on a small scale.** In France, the SME Hype Taxi partnered with Toyota to offer taxi services using around 180 FCEVs in Paris, as part of the Fuel Cell and Hydrogen Joint Undertaking (FCHJU) programme.[425] Hype Taxi also recently partnered with Stellantis to obtain 50 wheelchair-friendly FCEVs.[426] The production of these FCEVs was possible thanks to a new joint venture between Stellantis, Forvia and Michelin, called Symbio, which recently inaugurated Europe's

---

418 JRC. (2023). Supply chain analysis and material demand forecast in strategic technologies and sectors in the EU – A foresight study.

419 *Ibidem*

420 Johnson Matthey. (2024). Enabling fuel cell circularity with platinum. Available at: https://matthey.com/media/expert-insights/enabling-fuel-cell-circularity-with-platinum.

421 See: https://dashboard.tech.ec.europa.eu/qs_digit_dashboard_mt/public/sense/app/d58f3864-d519-4f9f-855e-c34f9860acdd/sheet/KVdtQ/state/analysis

422 See: https://dashboard.tech.ec.europa.eu/qs_digit_dashboard_mt/public/sense/app/6e4815c8-1f4c-4664-b9ca-8454f77d758d/sheet/bac47ac8-b5c7-4cd1-87ad-9f8d6d238eae/state/analysis

423 See: https://convion.fi/company/.

424 See: https://www.ekpo-fuelcell.com/en/company/joint-venture.

425 CHP. (2023). Success Stories 2022. Available at: https://www.clean-hydrogen.europa.eu/document/download/615adc83-31a5-4143-89e9-70f98ed96377_en?filename=Success%20stories%202022%20-%20All%20factsheets%20%28ID%2014686408%29.pdf.

426 Stellantis. (2023). Stellantis and Hype deploy a first fleet of 50 wheelchair-accessible hydrogen taxis in Paris. Available at: https://www.media.stellantis.com/uk-en/corporate-communications/press/stellantis-and-hype-deploy-a-first-fleet-of-50-wheelchair-accessible-hydrogen-taxis-in-paris.

largest gigafactory for hydrogen fuel cells in France, which aims to produce 50,000 fuel cells a year by 2026.[427]

- **Adopt and pioneer the use of fuel cell technologies** in different sectors, including construction,[428] aviation[429] and space exploration.[430] For instance, in January 2024, Nedstack, a Netherlands-based SME and manufacturer of PEMFC stacks and systems, and Groeneveldt, a specialist in workboats, signed a contract for the delivery of a portable fuel cell system, supplying power to a sustainable workboat for the Province of Overijssel. The system will serve as an emission-free range extender on board of the workboat, recharging the onboard battery when shore power is unavailable during longer working days.[431]

6.2.2 OSA goals and overview of relevant policy initiatives

Attempts to foster a hydrogen-based alternative mobility go back to the late 1990s, with the European Integrated Hydrogen Project, aimed at harmonising rules and safety requirements for hydrogen-based vehicles, while the first EU-funded demonstration projects for fuel cell technologies applied to mobility are from the mid-2000s.[432]

Since then, hydrogen technology has matured thanks to numerous projects. Today, transportation represents one of the pillars of the Clean Hydrogen Joint Undertaking (CHJU) Programme, also known as Clean Hydrogen Partnership (CHP). It reflects the “significant effort to develop, validate and demonstrate technologies for FC material handling vehicles, FC buses and FCEV passenger cars that can be considered ready for market deployment.”[433] As of early 2024, this pillar counts 25 ongoing EU-funded projects for mobility, covering seven different areas: building blocks (fuel cell stack and fuel cell system technology, and on-board vehicle hydrogen storage), heavy duty vehicles, waterborne, rail and aeronautic applications, buses and coaches, and passenger cars.

These projects aim to achieve the OSA goals of bolstering internal production and fostering circularity by advancing the development, validation and demonstration of technologies for fuel cell and FCEVs that can be considered ready for market deployment. The CHJU programme has also resulted in important successes.[434] For instance, the GAIA project delivered a strong power density for fuel cells without increasing platinum loading, which helps reduce reliance on critical raw materials.[435] Likewise, the 3EMOTION[436] and the JIVE/JIVE2[437] projects deployed over 300 FC buses across several European capitals, meeting targets on hydrogen consumption, warranty time and bus costs, thus showcasing the maturing of fuel cell technologies for mobility purposes and their market potential. In some cases, SMEs were

---

427 Reuters. (2023) Symbio inaugurates Europe's largest hydrogen fuel cell plant. Available at: https://www.reuters.com/business/energy/symbio-inaugurates-europes-largest-hydrogen-fuel-cell-plant-2023-12-05/

428 Construction Briefing. (2022). Can SME contractors be hydrogen powered?. Available at: https://www.constructionbriefing.com/news/can-sme-contractors-be-hydrogen-powered-/8023628.article.

429 See: https://hypoint.com/.

430 See: https://powerup-tech.com/esa-project/.

431 Nedstack. (2024). Nedstack Fuel Cell Technology B.V. partners with Groeneveldt Marine Construction B.V. to deliver a Sustainable Workboat with Mobile PEM fuel cell system for Province of Overijssel. Available at: https://nedstack.com/en/news/nedstack-fuel-cell-technology-bv-partners-groeneveldt-marine-construction-bv-deliver.

432 Bravo Diaz, L., & Boillot, L. (2024). *Historical Analysis of Clean Hydrogen JU Fuel Cell Electric Vehicles, Buses and Refuelling Infrastructure Projects*.

433 CHP. (2023). Programme review report 2023. Available at: https://op.europa.eu/en/publication-detail/-/publication/00f833fa-7ec4-11ee-99ba-01aa75ed71a1/language-en/format-PDF/source-296436320.

434 *Ibidem.*

435 See: https://www.gaia-fuelcell.eu/.

436 See: https://www.3emotion.eu/.

437 See: https://www.fuelcellbuses.eu/projects/jive and https://www.fuelcellbuses.eu/projects/jive-2.

heavily involved: the ZEFER project (which pilot-tested 180 FCEVs in three European capitals) counted six SMEs among the 15 partners, which received 84% of the total funding.[438]

At the same time, however, **the CHJU identified several gaps that make the achievement of OSA in this area more difficult**, especially given the already advanced stage of some Asian competitors.

- One of the major burdens for field tests is the **absence of a harmonised framework for permits and approvals of open-air pilot tests from Local Authorities**. The time taken to grant permits for on-the-road testing is still substantial, slowing down the capacity for further production development and commercialisation.
- **The certification process for FCEVs is very detailed and is a source of delay in project execution**. The requirements to obtain a registration plate (matriculation) for hydrogen trucks vary across Member States. This obstacle, too, slows down the capacity to adopt this new technology and its commercial viability.
- **A widespread application of PEMFC technology is constrained by the usage of expensive and rare materials, mainly PGMs**. There is a continuous challenge to maintain satisfactory performance and degradation rate of fuel cell stacks while minimising the use of PGMs.
- **Fuel cell buses encounter difficulties competing against the cheaper costs of battery electric buses**, mainly because of the increased prices of hydrogen at the pump triggered by the energy crisis, affecting the financial viability of the projects.
- There is a **lack of validated well-to-wheel data for FCEVs** to assess the environmental impact over the life cycle of the vehicle. Maintenance of FCEVs is still very expensive,[439] and since manufacturers tend to follow demand (which in the EU is still very low), there is little flexibility to increase the stock of spare parts.

These R&I efforts constitute, to date, the main field of activity for fuel cell technologies. The European Commission also approved three Important Projects of Common European Interest (IPCEI) on hydrogen to support and expand these efforts: Hy2Tech for hydrogen technology,[440] Hy2Use for industrial applications,[441] and Hy2Infra for infrastructure.[442]

Of these, Hy2Tech is the one that most explicitly focuses on fuel cell technology (see Figure 31). This IPCEI will provide up to EUR 5.4 billion in public funding, which is expected to unlock additional €8.8 billion in private investments.

More specifically, activities related to fuel cell technology for this IPCEI **aim to achieve four overarching goals**:

- **Increasing efficiency and reducing costs of fuel cells**. This is necessary to overcome the current market barrier in competition with existing technologies (e.g. batteries) and non-EU companies from South Korea and Japan in particular.

---

438 See: https://zefer.eu/.

439 Wang, J., Wang, H., & Fan, Y. (2018). Techno-economic challenges of fuel cell commercialization. *Engineering*, *4*(3), 352-360.

440 European Commission. (2022). State Aid: Commission approves up to €5.4 billion of public support by fifteen Member States for an Important Project of Common European Interest in the hydrogen technology value chain. Available at: https://ec.europa.eu/commission/presscorner/detail/en/ip_22_4544.

441 European Commission. (2022). State Aid: Commission approves up to €5.2 billion of public support by thirteen Member States for the second Important Project of Common European Interest in the hydrogen value chain. Available at: https://ec.europa.eu/commission/presscorner/detail/en/ip_22_5676.

442 European Commission. (2024). Commission approves up to €6.9 billion of State aid by seven Member States for the third Important Project of Common European Interest in the hydrogen value chain. Available at: https://ec.europa.eu/commission/presscorner/detail/en/ip_24_789.

- **Adapting system behaviour for specific applications at both the component and system levels**. This involves continued technical and data exchange between component and vehicle manufacturers, the former of which are more likely to be SMEs.
- Ensuring the entire life cycle of materials and components, including recycling. This will help, in particular, towards the OSA goal of fostering circularity.
- Standardising fuel cell technologies for the different use cases with testing and validation under real conditions. This was described at length in the paragraphs above, and it is a necessary step before scaling up production.

Figure 31. Technology Field distribution and participants in Hy2Tech IPCEI, 2022

Source: European Commission.[443]

[443] See: https://competition-policy.ec.europa.eu/state-aid/ipcei/approved-ipceis/hydrogen-value-chain_en.

Within the Hy2Tech IPCEI, eight SMEs are direct participants, and four of them focus on fuel cell technologies. **There is also scope for scale-up thanks to the investment provided by the IPCEI.** For instance, Elcogen, an Estonian SME focusing on SOFCs for stationary systems, will provide, within the context of the IPCEI, validation and integration of cells, stacks and modules into the IPCEI partners' system protypes, while also designing advanced pilot lines to enable industrialisation and mass production. However, the end goal for Elcogen is to build a gigafactory in Estonia thanks to the very results produced through these projects.[444] However, interviewees noted that there still exists a misalignment in timing between the very quick pipeline of projects related to hydrogen technologies and the relative slowness in approving the financial support provided by the IPCEIs that would help these SMEs scale up. Since European companies lack market readiness for mass commercialisation, they are more vulnerable to competition from non-EU – especially Asian – companies. Scaling up will require reaching out to larger non-EU markets, which Elcogen in particular is already doing thanks to investment from Hyundai's KSOE, as mentioned in the previous section.

SMEs will also help generate spillovers from this flagship investment. In particular, Advent, a Greece-based SME specialised in the development, manufacture and assembly of complete fuel cell systems, is working on a project – Green HiPo – that aims to create up to 650 job opportunities for qualified scientific and technical personnel.[445] Still, it is necessary to ensure that these projects do not overextend their reach by trying to apply hydrogen and fuel cell technologies where it is not necessary without striving for decarbonisation, as Japan's strategy has seemingly done (see Box 26).

Box 26: Japan's Basic Hydrogen Strategy and its pitfalls

Japan represents an example in which the proposed hydrogen strategy has been so overarching that it creates competition with other greener and more mature technologies, such as electric vehicles, solar panels and heat pumps, without providing additional value for decarbonisation.

In June 2023, the Japanese Ministry of Economy, Trade and Industry (METI) announced a revised hydrogen strategy, trying to address some of the shortcomings of the previous 2017 strategy. In particular, one of the reasons to update the strategy was to expand into overseas markets rather than just developing the domestic market, thanks to a budget of around EUR 20 billion.[446]

With regard to fuel cells specifically, the strategy aims to establish Japan's position as a platform provider by ensuring that Japanese fuel cells are available anytime and anywhere in the world. In particular, the key is cost reduction, which Japan aims to achieve by means of economies of scale by focusing on technologies that are not exclusive to individual applications (e.g. trucks and buses, forklifts, ships, etc.), but which can constitute the core of the value chain and that can be used throughout the entire value chain.

Japan aims to promote initiatives based on **three pillars**: (1) **the industrialisation of the fuel cell business** through support of business and the creation of demand clusters; (2) the establishment of **strategies from a global perspective**; and (3) the **increase of demand**

[444] See: https://ipcei-hydrogen.eu/page/view/f2177c0c-392a-4f92-ac5e-f59bed7cee51/elcogen-as-ee05

[445] See: https://ipcei-hydrogen.eu/page/view/b0b5cfa0-229b-4498-8427-7388d4d5d04d/advent-green-hipo-el02

[446] Agency for Natural Resources and Energy. (2023). Overview of Basic Hydrogen Strategy.https://www.meti.go.jp/shingikai/enecho/shoene_shinene/suiso_seisaku/pdf/20230606_4.pdf.
Hydrogen Insights. (2023). Japanese government allocates $21bn to clean hydrogen subsidies. Available at: https://www.hydrogeninsight.com/policy/japanese-government-allocates-21bn-to-clean-hydrogen-subsidies/2-1-1574077.
An example of overseas collaboration with New Zealand is the Halcyon Power joint venture between Tuaropaki Trust and Japan's leading construction company, Obayashi Corporation. This joint venture aims, among other goals, to encourage the uptake of FCEVs in New Zealand thanks to a more robust infrastructure, which the Obayashi Corporation will help build. See: https://www.halcyonpower.nz/.

in Japan in both the mobility and power segment and in the consumer sector (fuel cells for households). As the strategy document states:

"If Japan-made fuel cells are to be used for various [fuel cell] applications around the world, Japanese companies would hold the key position in the value chains, drive market growth, accelerate cost reductions, and contribute to a [decarbonised] world."[447]

However, despite being at the forefront of fuel cell technology development, Japan's Basic Hydrogen Strategy has been subject to harsh criticism. In particular, **the strategy has been criticised for focusing on too many low-priority sectors and wanting to expand hydrogen usage where there is no need**. For example, experts have questioned the effectiveness of home fuel cells for decarbonisation. Current home fuel cells work by reforming city gas to produce hydrogen, but the CO_2 generated by this reforming reaction is emitted as is (i.e. untreated). Therefore, to make such fuel cells effective in reducing CO_2 emissions, it is essential to either make direct use of a pure hydrogen source (that meets emission standards), such as green hydrogen, or to decarbonise city gas. At the moment, solar panels and heat pumps represent greener and more mature technologies. However, to date, only 20% of total energy in Japan is generated by renewable sources.[448]

Another critique is that **the focus on fuel cell vehicles is holding back the growth of the EV market in Japan** by delaying the entry of domestic manufacturers in the EV market, making them lose competitiveness vis-à-vis international competitors. Moreover, only around 5,000 fuel cell vehicles are currently registered in Japan against a target of 800,000 by 2030, which appears to be unrealistic given the current growth rates.[449]

In sum, while other regions such as the EU, the US and other G7 countries have positioned hydrogen as a means for both cutting GHG emissions and ensuring energy security, **Japan's hydrogen strategy is structured to build up hydrogen demand in all sectors of the economy, while reflecting an underlying desire to preserve existing facilities, systems, and industrial structures based on the procurement and use of fossil fuels**.[450]

Source: Authors' elaboration.

A summary of the risks and opportunities for SMEs involved in the fuel cell value chain in terms of achieving higher strategic autonomy is presented in Figure 32.

[447] METI. (2023). Basic Hydrogen strategy. Available at: https://www.meti.go.jp/shingikai/enecho/shoene_shinene/suiso_seisaku/pdf/20230606_5.pdf, p. 39.

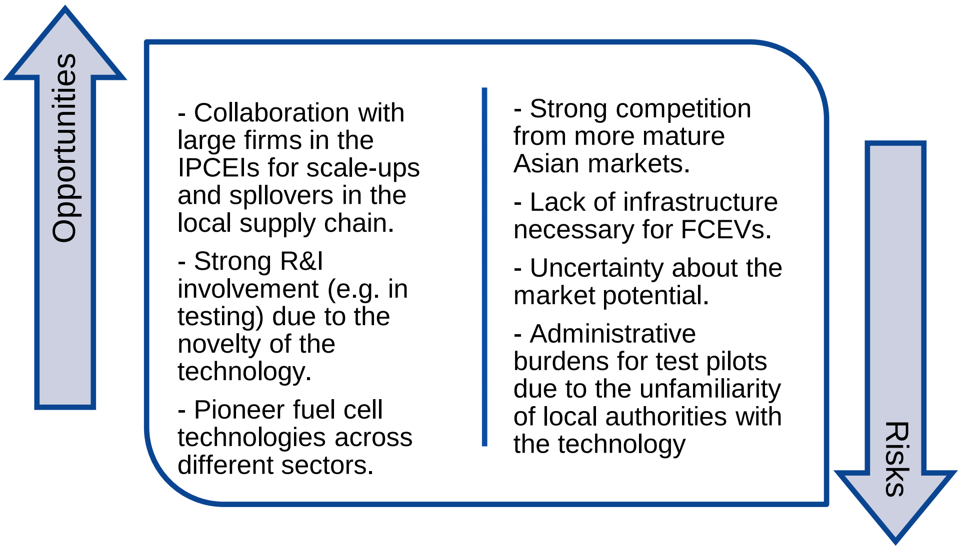
[448] Renewable Energy Institute. (2023). Revised Basic Hydrogen Strategy Offers No Clear Path to Carbon Neutrality. Available at: https://www.renewable-ei.org/en/activities/reports/20230720.php.

[449] *Ibidem*

[450] *Ibidem*

Hydrogen Insights. (2024). Greenwashing? | Hydrogen-based ammonia now being burned with coal at Japanese power plant. Available at: https://www.hydrogeninsight.com/power/greenwashing-hydrogen-based-ammonia-now-being-burned-with-coal-at-japanese-power-plant/2-1-1619033.

Figure 32. Opportunities and risks for SMEs from higher strategic autonomy in the battery value chain



Source: Authors.

6.2.3 Recommendations for future policy actions

Following the above analysis of the battery value chain, its vulnerabilities, opportunities and risks, and ongoing measures and projects, the following recommendations can be made to foster the involvement of SMEs in fuel cell development and production:

- **Enhance financial support for long-term goals.** European firms of all sizes – but especially SMEs – face important cost barriers. PGMs (platinum group metals) are expensive, as is the fuel cell stack, which can represent 45% of the entire system costs.[451] SMEs and mid-cap firms that may want to provide pilot tests for transportation services, such as Hype Taxi in France, may not be able to afford the costs of buying and operating a fuel cell fleet. Long-term subsidies or tax incentives specific to hydrogen mobility may help with offsetting the higher operational costs and make fuel cell cars and buses more competitive vis-à-vis both other technologies, such as battery electric vehicles (BEVs) and non-EU competitors with a strong footing in the fuel cell market, such as Japan and South Korea. The business association Hydrogen Europe estimates that the investment needed to deploy 45 GW of fuel cells yearly for both light- and heavy-duty vehicles would be around EUR 4.5 and EUR 9 billion while increasing fuel cell manufacturing capacity by at least 18 GW would require EUR 1.8-3.6 billion.[452] Such financial support would need to work along three lines:
  - R&D to find ways to reduce the costs needed to produce the fuel cells;
  - system integration and pilot testing, in which SMEs play a key role, and where cost reduction is important for SMEs' ability to adopt and test the technology;
  - infrastructure for hydrogen refuelling stations, without which the adoption of fuel cell cars, trucks and buses would not be scalable.

[451] Thompson, S. T., James, B. D., Huya-Kouadio, J. M., Houchins, C., DeSantis, D. A., Ahluwalia, R., ... & Papageorgopoulos, D. (2018). Direct hydrogen fuel cell electric vehicle cost analysis: System and high-volume manufacturing description, validation, and outlook. *Journal of Power Sources*, *399*, 304-313.

[452] Hydrogen Europe. (2023). Hydrogen Europe Position Paper – Net Zero Industry Act (NZIA). Available at: https://hydrogeneurope.eu/wp-content/uploads/2023/07/July_NZIA_HE_Position-paper.pdf.

- **Reassure investors and companies about the market potential.** Pilot tests have shown that fuel cell technologies are a valid clean and zero-emission alternative for commercial transportation. However, huge uncertainty still exists around the market potential of this sector. A first step would, therefore, be to assess the market potential for future investors in depth. Heavier public investment in the area (e.g. through the IPCEIs) that goes beyond the R&D stage, touching upon first industrial deployment, would also reassure investors and smaller companies about the commercial viability of these technologies. This would also encourage manufacturers in the supply chain to increase production flexibility and spare parts availability, which are constrained by the low demand in the European market. One way to do so would be to improve access to market-based financing, which would also benefit SMEs with more limited financial resources.
- **Promote clusters of collaborations for hydrogen mobility.** The high costs required in some parts of the value chain – namely, fuel cell stacking – prevent SMEs from fully utilising their innovative expertise in this area. Collaboration clusters, which would see SMEs benefit from access to larger firms' and research institutes' structures and technologies, would provide an efficient solution to overcome cost barriers. Some bilateral collaborations between SMEs and large firms already exist, as do joint ventures. However, national governments and public-private partnerships such as the CHJU could provide forums for networking and tighter collaboration between multiple companies. Such clusters could help accelerate fuel cell technologies' mass production and commercialisation and offer a protective shield against more vulnerable SMEs facing non-EU competition.
- **Provide certifications ensuring the quality of the technology.** At the moment, European companies cannot compete price-wise with their Chinese counterparts. One way to ensure that customers prefer European products is to provide labels/certifications establishing the performance quality of European-made fuel cells. The CHJU or other international partnerships or organisations may be in charge of providing such certifications. A similar initiative was undertaken, for instance, by the European Cyber Security Organisation (ECSO) in the field of cybersecurity.[453]
- **Promote alternative uses for fuel cells.** Several of the ongoing R&I projects involve road transportation (cars, buses, light commercial vehicles). However, firms may see a reduced market potential in this area due to the popularity and higher technology readiness level of BEVs. Policy-makers may, therefore, want to incentivise those sectors where BEVs may be less performant than FCEVs, such as long-haul transportation, maritime navigation, and aircraft applications. SMEs will indirectly benefit from this shift in focus in two ways: they will face reduced competition from other companies, and they may adopt and pioneer niche uses of fuel cell technologies.
- **Strengthen efforts towards standardisation and harmonisation of regulatory frameworks.** Hydrogen-based technologies require several certifications for safety reasons. However, there is still a lack of a harmonised regulatory framework across the several existing certification schemes. This may lead not only to market fragmentation (therefore limiting the scale-up potential of SMEs) but also deter companies from entering the market – especially SMEs, which may not have the human resources necessary to acquire the different certifications required. Such actions would require important actions such as public engagement, awareness campaigns, and up-and-re-skilling efforts.

[453] See: https://www.digitalsme.eu/cybersecurity-label/.

7 OSA and SMEs in the aerospace and defence (A&D) ecosystem

7.1 Dual-use technologies: Robotics and Drones[454]

Highlights:

- The Commission considers robotics and drone technology game changers for the Union and the MS. They enable and scale up domestic production, wealth, and military power and help reduce strategic dependencies.
- Cross-fertilisation between the aerospace and defence (A&D) sector and civilian application is possible. The civil applications of drones gained ground and dominated the market regarding the number of units sold with applications in agriculture, rescue missions, and provision of data for science, logistics, and commerce. However, the market size in terms of value is still dominated by military applications. Regarding robotics, service robotics is expected to displace industrial robotics[455] in terms of sales and market value over the next two decades. Exoskeletons (or wearable robotics) are also increasingly important, gaining market share in the future for civil healthcare and defence applications. Several countries, including the United States and China, are driving forces in exploring the potential of robotics, including drones in the defence sector and space exploration.
- The EU A&D robotics and drones industry encompasses a few large prime contractors (mainly based in Italy, France, Germany, Spain and Sweden) and many specialised SMEs that are more evenly distributed. Prime contractors lead the design and building of platforms, serving as system integrators and maintaining direct relationships with buyers, typically governments or national agencies. SMEs and mid-caps operate in lower supply chain tiers, and their contribution to the overall industry is minimal in terms of revenue and employment (between 3-5%) of the total.
- Despite their limited turnover, SMEs play a crucial role in the supply chain of robotics and drones for A&D applications, and their involvement is considered a necessary condition for achieving Europe's sovereign autonomy. SMEs bring innovation and specialised expertise, favour collaborative partnerships, and contribute to supply chain diversity while reducing the risk of over-reliance on a few key suppliers.
- Barriers linked to the market dynamics and the regulatory framework (and its role in accessing finance) limit the potential role of SMEs in the A&D sector, leaving room for public intervention.
- The European Drone Strategy 2.0 launched in November 2022, and the Commission's announcement about an EU-wide strategy in early 2025 to ensure coordination across the 27 MS in the uptake of robotics powered by AI, already indicates actions to prepare the way from synergies between the civil, security and military use of robotics and

[454] The term drones in this study refers to the comprehensive term comprising any type of unmanned vehicle (UV), including the less prevalent ones like unmanned ground vehicles, in addition to the mosty prevalent one unmanned aerial vehicles (UVAs). The latter refers to recoverable or expendable aircraft without a human operator on board

[455] Industrial robots and service robots both serve automation purposes but are primarily used in different contexts. Industrial robots are typically deployed in manufacturing settings or for tasks that might be hazardous, where they often take over roles previously held by humans. Conversely, service robots are employed across a broader range of sectors including healthcare, hospitality, and cleaning. Although service robots are also found in manufacturing, their principal function is to assist humans rather than replace them, focusing on "softer" tasks compared to their industrial counterparts.

related technologies, including counter-drone solutions. While the suggested actions also touch SMEs, it is worth investigating more targeted interventions for them.

This section offers an overview of the main issues related to OSA and SME development in the **aerospace and defence (A&D) ecosystem**. The focus is on **robotics**, which is a more general technology category, and drones are also included**.**

Robotics and drones are dual-use technologies with civil and military applications. While sharing a few vulnerabilities, especially for the supply of components, **the A&D market of robotics behaves quite differently from civilian applications in terms of regulatory framework, market dynamics, funding opportunities and considerations related to national security**. These factors make space and defence applications strategically relevant from the OSA perspective.

7.1.1 Overview of the value chain, positioning of SMEs and strategic vulnerabilities

The global supply chain of robotics and drones are very similar. They can be analysed in five steps (raw materials, processed materials, components, assemblies, and super-assemblies), as discussed in a report by JRC.[456]

The supply of raw material is dominated by China, with about 50% of the global production, followed by African (11-12%), Latin American (7-8%) countries, and other countries in the rest of Asia (7-8%). The EU produces a share of 3-4% of all the raw materials used to manufacture robots and drones domestically. In contrast, the EU is the second largest producer of processed materials (15-18% production share), along with the USA, which follows China with 34-37% of production capacity. However, the EU remains entirely dependent on China to supply several processed materials used in robotics and drones, such as specific alloys (aluminium, Platinum Ruthenium-based Catalysts) and Li-ion batteries (Section 7). Asian countries still dominated the supply and manufacturing of components, followed by Japan, and USA. When it comes to assembly, the EU is the second largest supplier of fuel cells (20%), but it remains fully or partial dependent on China for Li-ion and fuel cells batteries, with 75% and 66% of global production capacity. The EU is also the second largest supplier – together with Israel - of actuators (CPUs and GPUs).[457] and – together with US, of sensors.

Box 27: The Japanese monopoly of precision reducers components

In mechanical transmission, precision reducers are an indispensable part of the reliable and precise operation of industrial robots. The reducer is an intermediate device (gear) that connects the power source and actuator. Usually, the reducer uses the high-speed power of the motor and internal combustion engine to engage the large gear on the output shaft through the small gear on the input shaft to reduce speed and transfer more torque.

Driven by the development of aerospace and medical equipment, the demand for high-performance precision reducers with simple and compact structures, considerable transmission power, low noise, and smooth transmission has increased. Among them, RV reducers and harmonic reducers are the two most essential precision reducers. In articulated robots, because of the higher rigidity and slewing accuracy of RV reducer, RV reducer is generally placed at a heavy load motion such as the machine base, the boom, the shoulder, and the harmonic reducer is placed on the forearm, wrist or hand.

[456] Joint Research Centre (JRC) (2023) . Supply chain analysis and material demand forecast in strategic technologies and sectors in the EU – A foresight study. Available at https://publications.jrc.ec.europa.eu/repository/handle/JRC132889

[457] Joint Research Centre (JRC) (2023) . Supply chain analysis and material demand forecast in strategic technologies and sectors in the EU – A foresight study. Available at https://publications.jrc.ec.europa.eu/repository/handle/JRC132889

Two Japanese companies - Nabtesco and Sumitomo – control most of the global market of precision reducers and are the only ones that can provide large-scale and reliable performance devices. Currently, 75% of precision reducers in the global robot industry are monopolized by Japanese Nabtesco.

According to industry insiders, ABB, FANUC, Yaskawa, KUKA and other international mainstream robot manufacturers are all powered by the above two Japanese companies for reducer solutions and have very harsh conditions of cooperation with the two companies, that is, using products of the two companies can no longer use products of other companies, otherwise the cooperation relationship will be terminated.

Source: Authors' elaboration based on interviews with business association representative and documentary research.

The EU27 is home to a well-developed robotics market, including civilian and A&D applications (see Box 28). Regarding A&D, five EU countries (Italy, France, Germany, Spain and Sweden) and the United Kingdom account for the bulk of European aerospace defence expenditures. All the leading companies are headquartered in France, Italy, and Germany, explaining why these states dominate the industry. Together, they represent more than 60% of total EU A&D revenues. Similarly, these countries have the largest A&D spending, accounting for over 60% of all EU A&D spending.

Box 28: The European market of robotics, including civilian and A&D applications

The projected revenue for the robotics European market is estimated to be around EUR 12 billion, corresponding to 30% of the global market valued at about EUR 41 billion.

The robot market is categorised into two major segments, namely industrial robots (accounting for 80% of the current market) and service robots (20% of the current market, with almost half in logistics).[458] While the market of industrial robots is expected to grow because of the increasing uptake of so-called cobots[459], service robotics will displace industrial robotics in terms of sales and market value over the next decades.

Italy, Germany, France, Spain and Poland, which account for 70% of all industrial robots installed within the EU in 2022, are set to be the top five adopters of the coming robotics EU strategy. This makes Europe the second-largest global region in robotics uptake after China. In particular, the German market is one of the biggest markets for robotics and is estimated to grow with an annual growth rate in revenue higher than 14% in the next five years. Other markets like Spain, Italy, and the UK will also grow to become significant players in the service robotics market in the years to come.

Regarding the A&D application, the market value estimation is hard to predict because of the dual-use nature of this technology. Exoskeletons (or wearable robotics) are also of increasing importance, gaining market share in the future for both civil healthcare and defence applications. Moreover, in defence, both manned and unmanned types of robots are used. In unmanned use, drones are very common. The use of drones has increased in the battlegrounds for a few years. They are being used for intelligence, surveillance, and

[458] Industrial robots and service robots both serve automation purposes but are primarily used in different contexts. Industrial robots are typically deployed in manufacturing settings or for tasks that might be hazardous, where they often take over roles previously held by humans. Conversely, service robots are employed across a broader range of sectors including healthcare, hospitality, and cleaning. Although service robots are also found in manufacturing, their principal function is to assist humans rather than replace them, focusing on "softer" tasks compared to their industrial counterparts.

[459] Cobots are designed to work alongside human operators in a shared workspace, enabling human-robot collaboration in tasks that require close interaction & coordination.

reconnaissance missions and have helped the soldiers on the ground and sitting far away to plan their next move.

The empowerment of SMEs happens by both allowing them: (i) to be more productive and competitive through the use of robotic technology; (ii) by nurturing a new wave of robotics start-ups that will mature into the next successful robotics companies; (iii) Supporting SMEs in the realisation, testing and promotion of robotic technology for the market; (iv) complying with international standards and national standards depending on the destination markets.

Source: Authors' elaboration based on interviews with business association representative; Robotics – Europe by Statista Statista Market Insights, and on Mordorintelligence data. See https://www.mordorintelligence.com/industry-reports/europe-service-robots-market-industry

The European A&D industry consists of various companies, including very large prime contractors and specialised SMEs, with varying sizes. Prime contractors based in the leading countries listed above have the full responsibility to design, integrate and build civil, space or military platforms and serve as system integrators, establishing direct relationships with space and military buyers (often governments and national agencies) and specialised supplier companies, including SMEs and mid-caps, operating in the lower tiers of the supply chain.

SMEs and midcaps in defence-related technology, including robotics and drones, are more evenly geographically distributed across the EU27 and their number ranges from a lower boundary of 2,500 to an upper boundary of 3,800.[460] Their contribution to the overall industry is minimal in terms of revenue and employment. For instance, German SMEs employ 3,500 workers out of 65,000 A&D workers, equating to merely 5.4% of the value chain. Furthermore, their combined yearly turnovers contribute only 3.4% of the value's total turnover.[461] A similar phenomenon can be seen across all the other EU countries.

Despite the limited contribution to revenues and employment, **SMEs (and mid-caps) play a crucial role in the supply chain of robotics and drones for A&D applications**. They are represented downstream in the supply chain, especially in manufacturing small drones and components.[462] Their intense involvement is considered a necessary condition for the achievement of the sovereign autonomy of Europe in this field because of their:

- **Innovation and agility**. SMEs are often at the forefront of innovation in robotics and drone technology. Their smaller size makes them more agile and responsive to changing market demands and emerging technologies. They can quickly adapt to new requirements and develop specialised solutions tailored to specific aerospace and defence needs.
- **Specialised expertise** in niche areas of robotics and drone technology. They may focus on developing advanced sensors, lightweight materials, autonomous navigation systems, or specific components crucial for aerospace and defence applications. Their expertise often fills gaps in the supply chain that larger companies may overlook.

[460] These figures are conservative. They likely include companies with a high percentage of their turnover originating from defence and those actively developing products and services with proven military applications. See European Commission (2024), Access To Equity Financing for European Defence SMEs. Final Report, DG DEFIS, European Commission 2024. Available at https://defence-industry-space.ec.europa.eu/study-results-access-equity-financing-european-defence-smes-2024-01-11_en Instead, a non-exhaustive and ongoing-populated database of SMEs and mid-caps in the robotics value chain counts more than 300 companies active in Europe (see http://www.eu-robotics-sme.org/).

[461] European Commission (2024). Access To Equity Financing for European Defence SMEs. Final Report, DG DEFIS, European Commission. Available at https://defence-industry-space.ec.europa.eu/study-results-access-equity-financing-european-defence-smes-2024-01-11_en

[462] Kunertova, Dominika (2019). Military Drones in Europe. The European Defense Market and the Spread of Military UAV Technology

- **Collaborative partnerships** with larger corporations, research institutions, and government agencies to develop and integrate their technologies into broader aerospace and defence systems. These partnerships leverage the strengths of both parties, allowing SMEs to access resources and markets they might not reach independently.
- **Contribution to supply chain diversity**, reducing the risk of over-reliance on a few key suppliers. This diversity enhances resilience and mitigates potential disruptions, ensuring a more robust and stable supply of critical components and technologies for robots and drones. Indeed, the (future) resilience of the supply chain is linked to the significant contribution SMEs already (or can additionally) provide to innovation, flexibility, and niche expertise within robotics and drone applications.

7.1.1.1 Barriers for SMEs

Against this role of SMEs, some barriers limit their involvement in this area, and that can be exacerbated with OSA-related policies leaving room for public intervention to support and nurture these firms to maintain Europe's leadership in this strategic sector. Barriers include, e.g., the increasing need for confidentiality and secrecy of information for a specific technology, regulations to limit imports (and exports), limitations to FDI from extra EU companies in A&D-specific segments, and so on. They can be divided into two main types: barriers related to the A&D market structure and those linked to the sector-specific regulatory frameworks.

The market structure

The dependency on public contracts or large prime contractors is an element of the fragility of the supply chain. A&D technology markets feature an oligopoly characterised by a highly specialised industry, often politically supported. The industry operates with a few dominant contractors who maintain entrenched relationships with government officials and agencies and possess extensive knowledge of the acquisition process, which may be unfamiliar to companies operating downstream in the supply chain. Moreover, interviews highlighted that the consolidation and mergers between departments in the national public administration resulted in increasing budgets for projects to be spent in shorter periods, hampering access to SMEs, which often do not have the requirements and expertise to manage big projects. On top of that, each European (national) market has its A&D procurement processes, and companies need to understand them individually.

Moving down in the supply chain, its **diversity is also jeopardised by the fact that prime contractors have their own approved direct suppliers** with a robust quality management system in conformity with the stringent technical requirements that robots and drones need to fulfil A&D duties.[463] The specification, method of production, and physical and chemical properties of any raw material used in any equipment are pre-defined. This means that not all suppliers are able to provide the purity required for a particular critical application. The market thus tends to concentrate around a selected list of producers, generating a cascade of barriers to market entry for other suppliers while increasing the vulnerability of the supply chain and associated obsolescence risks.[464] This is why it is necessary to increase diversification by attracting new SMEs and start-ups via funding opportunities and communication actions, including industry events where the actors (investors, SMEs, and large players) can meet each other (see Sections 7.1.2 and 7.1.3).

[463] KPMG (2020), 'Military materials. Challenges and opportunities', https://assets.kpmg

[464] Joint Research Centre (JRC) (2020) . Critical Raw Materials for Strategic Technologies and Sectors in the EU– A foresight study. Available at https://rmis.jrc.ec.europa.eu/uploads/CRMs_for_Strategic_Technologies_and_Sectors_in_the_EU_2020.pdf

The sensitivity and confidentiality of information can also significantly hinder the entry of new producers. Start-ups and SMEs may be unable to access critical information and technological needs of governments and agencies due to national security concerns, making it difficult to penetrate the market. Interviews revealed that these difficulties span all A&D technologies.

Investing in the A&D technology often entails a longer investment horizon than other industries, rendering it relatively less appealing for SMEs. Developing innovative A&D robots and drones demands significant effort, typically 5 to 10 years, involving meticulous development, rigorous testing, and thorough validation to meet stringent standards. The high capital costs, including R&D, and extended timelines for investment returns make the sector incompatible with many start-ups that need rapid rewards and unattractive to SMEs. This is exacerbated by the greater aversion to risk of the A&D applications due to the limited number of potential buyers unless the technology serves civilian, space, and military purposes.

The regulatory framework and its role in SMEs' accessing finance

Exclusion policies of banks and investors to secure funds for the A&D sector (particularly defence) are not a recent phenomenon; however, they appear to have increased their impact recently. The introduction of regulatory measures focusing on financial accountability, environmental sustainability, and social responsibility has brought greater transparency and scrutiny regarding the activities of companies and investors in terms of Environmental and Social Governance (ESG) factors. Concurrently, these policies have spurred the adoption of exclusion policies targeting activities perceived by investors as posing sustainability risks.

Misinterpretations of ESG criteria can result in denying essential financial services, especially to defence companies, even those involved in dual-use technologies.[465] Consequently, many financial institutions have chosen the most straightforward and least risky option: excluding defence stocks from sustainable investment funds. Alternatively, some investors adopt a more stringent approach, eliminating the defence sector from all their investment portfolios (Box 29). An investor survey conducted by Deutsche Bank in 2022 showed that 15% of North American investors think defence should be excluded from ESG investments, while this goes up to 57% in Europe[466]. **These challenges are not confined solely to major system providers but extend to SMEs along the supply chain.**

In this regard, European institutions (e.g., the Commission), financial providers (EIF and EIB), and national promotion banks have a solid influence in facilitating access to finance for SMEs involved in dual-use technology. When these organisations are willing to provide public grants and loans and invest in A&D companies, it sends a powerful signal that the private sector is likely to echo.[467] The Commission president's speech to the European Parliament Plenary on 29 February 2024 about the urgency for Europe to invest in defence technologies and industrial capacity signals a public effort in this direction in the future.[468]

Box 29: European banks' loan policies for the defence and dual-use technologies

[465] European Commission (2023). Access To Equity Financing for European Defence SMEs. Final Report, DG DEFIS, European Commission. Available at https://defence-industry-space.ec.europa.eu/study-results-access-equity-financing-european-defence-smes-2024-01-11_en

[466] Axa Venture Partners (2023). Who will fund the next innovation wave in European Defence Technologies?

[467] Aurélie Pugnet (2023). EU defence industry pressures Commission, EU countries to step up financing, EURACTIV.com 27June 2023.

[468] Science | Business (February 29, 2024). Europe must urgently invest in defence technologies, says Ursula von der Leyen. https://sciencebusiness.net/news/european-defence-fund/europe-must-urgently-invest-defence-technologies-says-ursula-von-der?utm_source=ActiveCampaign&utm_medium=email&utm_content=Europe+must+urgently+invest+in+defence+technologies%2C+says+Ursula+von+der+Leyen&utm_campaign=Science%7CBusiness+Bulletin+No++1191+%28Copy%29

Banks, including national development banks, have developed specific policies for the A&D (particularly defence) sector within the ESG framework to ensure responsible conduct and mitigate reputational risks. They aim to balance national or European security concerns with the need to protect civilians, implementing rigorous internal protocols. These policies deal with principles and criteria governing operations within the defence sector, encompassing i) the nature of defence assets encompassed by the transaction, ii) the recipient of the transaction, iii) the counterparty involved in the operation, and iv) the destination country of the goods subject to the operation. The following three main policy cases can be distinguished:

- Restrictions on specific products (biological or chemical weapons), but also extended to dual-use technology, e.g., drones when employed for defence-related activities. Some banks confine their financing within the boundaries set by international treaties, conventions[469], sanctions (as stipulated by the EU and US), export control regimes[470], and national legislation.
- Other banks impose more stringent criteria grounded in an evaluation of the revenue composition of A&D enterprises (the share of revenue derived from "military" sources), in addition to international and national legal restrictions (the percentage of revenue derived from "military" sources). For instance, an Italian large commercial bank considers a company eligible for financing if the company's source of revenues is mainly from civilian origin (over 60% of total revenue in the previous fiscal year), otherwise finance is denied. Similarly, if more than 30% of the military-origin revenue is generated from countries deemed high-risk (e.g., marked by political instability, rampant corruption, or terrorism).
- A few banks completely prohibit financing for the defence sector, including dual-use goods and services.

Source: Authors' elaboration based on interview and European Commission (2024). Access To Equity Financing for European Defence SMEs. Report by DG DEFIS available at https://defence-industry-space.ec.europa.eu/study-results-access-equity-financing-european-defence-smes-2024-01-11_en

Moreover, **regulations governing foreign direct investment (FDI) protect domestic production while deterring extra-EU equity investors** looking to invest in the defence sector. These factors directly affect the valuation and development of SMEs operating within this industry. Unlike many other sectors, transactions involving defence-related companies/technologies are subjected to rigorous scrutiny by governments, which possess the power to veto transactions, especially when foreign entities are involved in the deal. Controls on FDI restrict the exit options for investments in defence-related ventures and present considerable obstacles to the growth potential and valuation of start-ups and SMEs developing dual-use technologies, including robots and drones.

469 E.g. Cluster munitions as defined by the 2008 Oslo Convention; Anti-personnel mines as defined by the 1997 Ottawa Convention; Biological or toxin weapons as defined by the 1972 Convention; Chemical weapons as defined by the 1993 Paris Convention; Nuclear weapons programmes of non-nuclear-weapon States under the 1970 Non-Proliferation Treaty; Depleted uranium ammunition, as prohibited by the Belgian law of 1999; Equipment having "no practical use other than the imposition of death penalty, torture or other cruel, inhuman or degrading treatment or punishment", as defined by Regulation (EU) 2019/125 of the European Parliament and of the Council of the European Union.

470 The Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies; the Nuclear Suppliers Group, for the control of nuclear and nuclear-related technology, the Australia Group for the control of chemical and biological technology that could be weaponized, the Missile Technology Control Regime for the control of rockets and other aerial vehicles capable of delivering weapons of mass destruction. While not formally an export control regime, the Zangger Committee has developed guidance on nuclear export restrictions required by the Non-Proliferation Treaty.

7.1.2 OSA goals and overview of relevant policy initiatives

In January 2024, the Commission announced that in early 2025, it will publish an EU-wide strategy paper to ensure coordination across the 27 MS in the uptake of AI-powered robotics.[471] The strategic document has followed a coordinated action plan on robotics published by the Commission in 2021 that encouraged member states to set up national robotics plans. It is now expected that EU countries will be asked to provide an overview of their domestic strategies, which will form the basis of consultation meetings on the bloc-wide strategy, which is scheduled to start in the first months of 2024. The strategy will link with other relevant European Commission plans, such as the Workplace AI Initiative and the AI innovation package to support Artificial Intelligence start-ups and SMEs, which follows the political agreement reached in December 2023 on the EU AI Act (see also Section 5.1).[472]

AI robotics is a critical game changer to scale up domestic industrial production and ensure military power.[473] Software-related robotics challenges include the ability to perform more and more intelligent tasks using complex software architectures. The technology involves but is not limited to novel robotic structures, mobile robots, manipulators, sensing technology, gripping and actuation mechanisms, navigation and control software, and perception, among many other areas with the main application in healthcare, agriculture, manufacturing, defence and other areas.[474] Specifically, service robotics is scaling successfully in application fields such as transport and logistics, laboratory automation, the hotel industry and professional cleaning,[475] while exoskeletons (or wearable robotics) are gaining increasing market share for civil healthcare and defence applications. Several countries, including the United States and China, are driving forces in exploring the potential of robotics in the defence sector and space exploration Box 30).[476]

Box 30: China's ambitious 5-year Plan for Robotics (2020 - 2025)

China's robotics industry is set to become self-sustaining and "leapfrog over generations." Cutting-edge technologies, such as bionic perception and cognition, biomechanical-electric fusion, AI, 5G, big data and cloud computing, will drive robotics development.

Robotics standardisation and certification work will be improved and contribute substantially to the above goal. Service robots will be increasingly deployed in agriculture, mining, construction, medical rehabilitation, housework, safety supervision, catering and delivery, and traffic management. Special robots will be used for underwater exploration, security and defence, and rescue operations.

Implemented actions include: (i) strengthening coordination among the main players (firms investors, business associations, policy-makers), (ii) increasing financial and fiscal support, (iii) creating a good market environment, also in terms of firms-friendly regulation; (iv)

---

[471] The strategy paper on Robotics will be linked to other relevant commission plans, such as the AI in Workplace initiative and the AI Act. Moreover, it follows a coordinated action plan on robotics published by the commission in 2021, which encouraged member states to set up national robotics plans. They will feed the pan-EU strategy scheduled for 2025.

[472]https://digital-strategy.ec.europa.eu/en/news/commission-launches-ai-innovation-package-support-artificial-intelligence-start-ups-and-smes Last access on 18/03/2024

[473]Joint Research Centre (JRC) (2023) . Supply chain analysis and material demand forecast in strategic technologies and sectors in the EU – A foresight study. Available at https://publications.jrc.ec.europa.eu/repository/handle/JRC132889
Dear, K. (2021), ´Beyond the 'Geo' in Geopolitics´, The RUSI Journal, Vol. 166(6-7), pp. 20-31, DOI: 10.1080/03071847.2022.204916

[474]Joint Research Centre (JRC) (2023) . Supply chain analysis and material demand forecast in strategic technologies and sectors in the EU – A foresight study. Available at https://publications.jrc.ec.europa.eu/repository/handle/JRC132889
Dear, K. (2021), ´Beyond the 'Geo' in Geopolitics´, The RUSI Journal, Vol. 166(6-7), pp. 20-31, DOI: 10.1080/03071847.2022.204916

[475] VDMA Robotics + Automation (2024). Strategy Paper Robotics and Automation 2028 Key Technology for Germany.

[476] Joint Research Centre (JRC) (2023). Supply chain analysis and material demand forecast in strategic technologies and sectors in the EU – A foresight study. Available at https://publications.jrc.ec.europa.eu/repository/handle/JRC132889

strengthening IPR protection; (v) cultivating talent in robotics and, (vi) by deepening international exchange and cooperation.

Source: Authors' elaboration based on interviews with business association representatives, International Federation of Robotics | IFR), and VDMA Robotics + Automation.

Similarly, **the European Drone Strategy 2.0 adopted by the Commission in November 2022 sets out a vision for further developing the European drone market and helping reduce strategic dependencies**. It was designed to prepare the way for large-scale commercial operations and ensure that Europe benefits from synergies between the civil, security and military use of drones and related technologies, including counter-drone solutions.[477] Indeed, while the civil applications of drones gained ground in the most recent years in terms of units sold in different fields of application such as agriculture, provision of data for science, logistics and commerce, the market size in terms of value is still dominated by space and military applications.[478] The production capacity of drones, especially unmanned aerial vehicles (UVAs), has increasingly advanced in the last decade, particularly for tactical, surveillance, and other military applications globally and in the Middle and Near East in particular

The Strategy envisages 19 specific operational, technical and financial actions (also relevant for SMEs) (Table 9) to achieve four overarching objectives: (i) adopting common rules for airworthiness and new training requirements for remote and eVTOL[479] aircraft pilots; (ii) funding the creation of an online platform to support local stakeholders and industry implementing sustainable innovative air mobility; (iii) developing a strategic drone technology roadmap to identify priority areas for research and innovation, to reduce existing strategic dependencies and avoid new ones arising; (iv) defining criteria for a voluntary cybersecurity-approved drone label.

Table 9. Flagship actions under the European Drone Strategy 2.0

Flagship action	Description
1	Adoptions of amendments to the Standardised European Rules of the Air and the Air Traffic Management/Air Navigation Services Regulation to safely integrate drone and piloted eVTOL (electric vertical take-off and landing)operations.
2	Continuation to promote coordinated research on integrated Communication, Navigation and Surveillance technologies to ensure the convergence between ATM (Air Traffic Management) and U-space environments.
3	Adoption of new European standard scenarios for low to medium risk aerial operations
4	Adoption of rules for the 'certified' category of drone operations, addressing the initial and continued airworthiness of drones subject to certification; and the operational requirements applicable to manned VTOL-capable aircraft
5	Adoption of rules for the design and operations of vertiports under the scope of the EASA Basic Regulation
6	Developoment of balanced economic and financial requirements for licensing of drone operators.
7	Funding the creation of an online platform to support a sustainable IAM implementation by authorities, communities, municipalities, industry and stakeholders.
8	Adoption of new training and competences requirements for remote pilots and pilots of VTOL aircraft5
9	Coninuting to provide funding for R&I on drones and their integration into the airspace under the Horizon Europe programme and the European Defence Fund
10	Setting up a coordinated series of calls under the existing EU instruments and EIB loans to support a new flagship project on 'drone technologies.'
11	Consider possible amendments to the existing financing/funding framework to ensure a consistent approach supporting dual-use research and innovation to improve synergies between civil and defence instruments.
12	Developing a Strategic Drone Technology Roadmap to identify priority areas to boost research and innovation, reduce existing strategic dependencies and avoid the emergence of new ones
13	Coordination with other relevant EU actors is a common approach to providing sufficient radio frequency spectrum for drone operations.

[477] https://ec.europa.eu/commission/presscorner/detail/en/ip_22_7076

[478] Colin Laure and Alain Grandjean (October, 2022). Military drones: current trends in the market. École Polytechnique insights (iP Paris). Available at https://www.polytechnique-insights.com/en/columns/geopolitics/military-drones-current-trends-in-the-market/ Last access on 13/03/2024.

[479] eVTOL stands for « Manned Electric Vertical Take Off and Landing »

Flagship action	Description
14	Setting up an EU network of civil-defence drone testing centres to facilitate exchanges between civilian and defence sectors.
15	Encouraging all relevant actors to further align certification requirements for civil and military applications towards those set by EASA while considering military specificities and existing military certification standards.
16	Adoption of new standard scenarios for civil operations that could facilitate corresponding military use cases
17	Adoption of a counter-drone (C-UAS) package
18	Adoption of an amendment to the aviation security rules aiming to ensure that aviation authorities and airports increase their resilience when faced with the risks posed by drones
19	Definition of criteria for a voluntary "European Trusted Drone" label: The Commission intends to adopt amendments to the Standardised European Rules of the Air and the Air Traffic Management/Air Navigation Services Regulation to integrate drone safely and piloted eVTOL (electric vertical take-off and landing)operations.

Source: Authors based on the Commission's European Drone Strategy 2.0

European direct funding programmes aiming to enhance innovation capacity and industrial capacity, including supply diversification for robotics and drones targeting A&D applications, but not only include:

- The **European Defence Fund (EDF)** provides public grants to fund cross-border cooperation on R&D actions with the defence applications, including those related to robotics and drones. The Fund has a nearly EUR 8 billion budget for 2021-2027, with EUR 2.7 billion allocated for collaborative defence research and EUR 5.3 billion for collaborative capability development projects that complement national contributions. It is designated to stimulate SMEs' participation and help open up the defence supply chains, linking the large system integrators with the entire defence ecosystem across the EU. **Dedicated calls have been introduced targeted at SMEs, including mid-caps,** in the work programmes that set annual funding priorities for research and development actions. Only consortia consisting of SMEs can apply to these specially designed calls. When assessing project proposals, including **cross-border SMEs is one of the award criteria**. Furthermore, financial bonuses are applied for development actions based on the level of involvement of (cross-border) SMEs.[480] The participation of SMEs is also encouraged via other lines of action. Within the framework of the EDF, the Commission, for the first time, opened new types of calls supporting defence innovation under the EU Defence Innovation Scheme (EUDIS), totalling EUR 224 million. Spin-in calls were opened to support SMEs' R&D for disruptive technologies to test, accelerate, and migrate innovation from civil to defence. Calls for business coaching for grant receivers proved highly successful. In 2023, the EDF received a record number of proposals since the establishment of the Fund in 2021, with an overall 76% increase in 2022. [481] Additional calls to empower SMEs in the ecosystem (e.g. business accelerator and matchmaking) are expected in 2025. [482] Two antecedent programs were the Preparatory Action on Defence Research (PADR) and the European Defence Industrial Development Programme (EDIDP).
- **Horizon Europe (HE)** provides funding for collaborative research projects to advance technology development in various sectors, including A&D. Among others, it enhances industrial capacity and competitiveness in robotics and drones for aerospace and

[480] See EDF eligibility rules. https://defence-industry-space.ec.europa.eu/eu-defence-industry/european-defence-fund-edf-official-webpage-european-commission_en#Eligibility

[481] European Commission. (2023). Record high number of proposals received in the 2023 round of the European Defence Fund. Available at: https://defence-industry-space.ec.europa.eu/record-high-number-proposals-received-2023-round-european-defence-fund-2023-11-24_en.

[482] EUDIS EU DEFENCE INNOVATION SCHEME - For European Defence Innovators. (2024). Available at: https://defence-industry-space.ec.europa.eu/document/download/96df9642-bb76-4cf6-bb0a-381ff8b570d1_en?filename=EU%20Defence%20Innovation%20Schemehttps://defence-industry-space.ec.europa.eu/document/download/96df9642-bb76-4cf6-bb0a-381ff8b570d1_en?filename=EU%20Defence%20Innovation%20Scheme%20Factsheet%202024.pdf%20Factsheet%202024.pdf

defence applications. The European Innovation Council (EIC) under HE supports innovations with potential breakthroughs and disruptive nature with scale-up potential that may be too risky for private investors. 70% of its budget is earmarked for SMEs.

At the national level, France is the only MS where SMEs developing defence technology can access generic and tailored financial instruments.[483] Other MS have adopted different approaches, often influenced by the relative importance of the A&D sector for their economy. In Italy, the national promotional bank - Cassa Depositi e Prestiti - released its policy for financing companies in the sector of defence technology and security in December 2022[484], acknowledging that this sector is strategic for ensuring sovereignty and it is, at the same time, one of the most debated sectors in terms of compatibility with ESG criteria. In Germany, Kreditanstalt für Wiederaufbau (KfW) does not have a specific mandate for the defence industry.[485] Denmark has set out its vision to develop the next generations of robots. The goal is to create an international hub to develop, test and produce robotics to be used in various environments (water, land, and air) and different tasks where digitalisation and automation are currently relatively low, such as the construction of ships in the maritime domain, wind turbine foundations in the energy sector and construction in general. The realisation of potential is based on the current establishment of the Centre for Large Structure Production (LSP) at Lindø (also supported by EU-REACT funds). In the area of autonomous systems, the business lighthouse for the future industry and the next generation of robots (The Business Lighthouse on Funen) is strengthening the conditions for the development, testing and demonstration of both flying and maritime autonomous drones. This is done based on the environment and facilities around Hans Christian Andersen Airport and the South Funen Archipelago. Both the LSP centre and the autonomous solutions focus on dual-use applications to meet the civilian and security interests of Denmark and its allies.[486]

Relevant examples of programs to access finance for firms, including SMEs, outside the EU are from the United Kingdom and the United States. Both nations are distinguished by their extensive support structures, with an increasing focus on dual-use technologies, enabling the transition of technologies from the civilian market into the military sphere and vice versa (Box 31).

Box 31: Examples of programmes to access finance opportunities in the UK and the USA.

The National Security Strategic Investment Fund (NSSIF) acts as the UK Government's venture capital arm dedicated to dual-use advanced technologies. It targets 12 key areas: cybersecurity; data analysis and artificial intelligence; audio and visual processing; commercial space technologies; platforms and robotics; biological and medical technologies; computational behavioural analysis; financial technologies; identity technologies; novel and data transport systems; IoT and adapting environments; sensors; novel materials and power sources; and quantum technologies. NSSIF co-invests alongside other investors, focusing on long-term equity commitments. It collaborates with a select group of leading venture capital funds and also provides financial support to other institutional VC funds.

---

483 BpiFrance allows the financing of pure defence companies and has deployed three types of financial products to support the sector: the investment fund Definvest, the equity fund Fonds Innovation Defence, and the loans DEF'FI

484 Cassa depositi e prestiti, 2022. Defence and Security Policy. 14 December, 2022.

485 However, companies in the sector can apply for subsidised loans, provided that the company is not engaged in activities on the exclusion list to all KfW programs, such as producing controversial weapons.

486 Source: SME envoy from Denmark.

The Defence & Security Accelerator (DASA) is a cross-government entity established by the UK Ministry of Defence (MoD). It welcomes innovators of all sizes and directly connects to the Defence Innovation Accelerator for the North Atlantic (DIANA), a NATO innovation initiative. The focus of the organisation is primarily on mid-TRL (Technology Readiness Level) technologies. Funding is provided through grants and various financial instruments, utilising different approaches such as Themed Competitions, Open Calls for Innovation, Defence Innovation Loans, the Defence and Security Seed Fund, and the Defence Technology Exploitation Programme (DTEP).[487]

Compared to many other countries, the United States offers extensive public funding programs tailored to support the defence industry, including the provision of loans and equity support. **For instance, the Defence Production Act (Dpa) loans and the Defence Export Loan Guarantee (DELG)** are two State-guaranteed loan programmes established in 1950. The main objectives are respectively: (i) to support the US military needs through loan facilities allocated to the defence, aerospace and security sectors; (ii) promote internationalization, bolster the defence industrial base, ensure capital access for defence stakeholders, mitigate contract risks, and foster innovation in the national defence sector. Targeted areas include any sectors, technologies, or activities identified as critical for the national industrial defence sector.[488]

In addition, **the implementing agency AFVentures provides Equity funding to US defence SMEs and midcaps.** Dedicated programmes such as Tactical Funding Increase (TACFI) and Strategic Funding Increase (STRATFI) support SMEs and midcaps in developing innovation, technology or research activities identified as crucial for the Air Force. Established in 2018, they also facilitate the commercialization efforts of these technologies.

Source: Authors' elaboration based on European Commission (2024). Access To Equity Financing for European Defence SMEs. Report by DG DEFIS available at https://defence-industry-space.ec.europa.eu/study-results-access-equity-financing-european-defence-smes-2024-01-11_en

7.1.3 Recommendations for future policy actions

The European Drone Strategy 2.0 and the strategic plans to create a European market for robotics powered by AI, along with the willingness of the Commission to invest more in defence applications in the future, represent a big step forward for the development of key technology in this sector. However, swift action is needed to address the barriers SMEs and mid-caps face to join the value chain and ensure that the European robotics and drone industry can meet escalating demands to protect national security while maintaining global competitiveness.

- **Set up more ambitious public European/national funding programs to strengthen cutting-edge research in dual-use robotics** by either expanding the existing capped-threshold funding instruments for SMEs (e.g., HE- EIC) or introducing new dedicated funding instruments. Developing innovative A&D robots and drones is a demanding process that typically spans 5 to 10 years, involving meticulous development and high capital costs for R&D. This makes the sector incompatible with many start-ups seeking rapid rewards and unattractive to SMEs. While steps forwards have been done recently with dedicated public funds specific to the sector for joint industrial research (e.g., EDF)

[487] Defence and Security Accelerator, 2023, DASA Annual Review 2021-2022. Available here: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1122390/DASA_Annual_Review_2021-22_FINAL.pdf.

[488] US Federal Emergency Management Agency (FEMA), 2023

or more generalist funds (HE- EIC), a funding gap still exists in the dual-use applications, leaving room for more massive public funding intervention.[489]

- **Diversification of funding opportunities by ensuring better access to venture/private capital to SMEs with specialised funds.** As discussed, securing financing for A&D companies entails substantial administrative expenses and intricate due diligence procedures to align with diverse national and international treaty regulations, such as export controls and sanctions regimes, including misinterpretation or over-prudency in applying ESG criteria. Limitations in the FDI further exacerbate access to extra-EU private funding. This results in increasing operational costs for firms, prolonging the approval and disbursement timeline, thereby impacting the agility and responsiveness of financial institutions**.** The EU equity facility for the space sector Cassini is an example that can be replicated in dual-use robotics technology. The Defence Equity Facility (DEF) announced by the Commission and the EIF in January 2024 goes in this direction[490] An example at the national level, even if not strictly related to robotics, is the German DeepTech & Climate Fund (DTCF), born to fill-in a financial gap in this niche. It supports early- and later-stage SMEs involved in deep tech that need external financing.

- **Support SMEs in realising, testing, and promoting robotic technology by engaging competence centres and mentoring them to complete the chain from "idea to market" product**. A&D technology needs rigorous testing and validation to meet stringent standards. Competence centres can provide state-of-the-art testing infrastructure and facilities tailored to the specific needs of the A&D sector. These facilities may include specialised laboratories, testing grounds, and simulation environments capable of replicating real-world scenarios. Typically, competence centres also house experts with specialised knowledge and experience. These professionals can offer invaluable insights into testing methodologies, standards compliance, and validation procedures, ensuring that technologies meet the required performance criteria.

- **Enhance the ability of A&D SMEs – especially newcomers – to comply with international and national standards, thereby expanding their market reach and competitiveness in destination markets**. Actions to achieve this can be: (i) tailored assistance programs delivered, e.g., by industry associations or dedicated organisations such as competence centres. They may offer certification and accreditation services to validate the performance and reliability of A&D technologies; (ii) training and workshops with sessions that may cover topics such as quality management systems, product certification, and regulatory compliance; (iii) networking, where SMEs can benefit from collaborating with larger companies, research institutions, and industry partners that have experience navigating international and national standards compliance. Networking opportunities facilitate knowledge sharing and exchange of best practices.

- **Facilitate the SMEs' access to relevant information and market needs via matchmaking initiatives for investors, A&D SMEs, business associations, and policymakers**. These initiatives could take the form of workshops or targeted or targeted networking events. They can inform SMEs and investors about the unique

[489] The public procurement argument will not be developed further. The procurement practises in the defence / dual-use sector, how to involve SMEs and the feasibility of having a pan-European procurement or standardised rules overcoming national fragmentation is discussed in the report «Access To Equity Financing For European Defence SMEs » by DG DEFIS. See also the link below for the legal feasibility and the European-wide public procurement in general. https://www.europarl.europa.eu/RegData/etudes/ATAG/2016/593571/EPRS_ATA(2016)593571_EN.pdf

[490] https://sciencebusiness.net/news/dual-use/eu-launches-eu175m-equity-fund-prime-private-investment-defence-rd

features and opportunities within the dual-use sector while enabling SMEs to better understand investor expectations, governments and agencies' technology requirements. Moreover, the involvement of industry associations can directly promote the developed solutions to their members, addressing a wide range of industrial sectors and applications.

- Regarding how to **make public procurement more SME-friendly**, the SMEs developing defence technologies share the same barriers as SMEs in space. Therefore, public procurement recommendations are discussed under the “Space Systems” technology.

7.2 Space systems

Highlights:

- **Space systems technologies, specifically space launchers and satellites, allow the EU to protect its space assets, defend its interests, deter hostile activities in space and strengthen its strategic posture and autonomy**. Today, more than 65 countries are involved in space activities. Still, only a few of these states (mainly the US, China, Russia, Western Europe, Japan and India) have the industrial and technical capacity to manufacture and operate their satellites and launchers. The competitors of the EU in this field are, at the same time, also the leading suppliers of critical and strategic (raw) materials and components for space systems.
- **About 400-500 SMEs contribute to the European space supply chain**. Only a few are 'pure' space players, while most comprise aerospace businesses operating in different ecosystems (automotive, health, defence and security, digital public services). The SME workforce represents about 10% of the total employment, and the majority of SMEs in the space supply chain are located close to the large industrial groups in France, Germany, Italy and, to a lesser extent, the UK (as full members of the ESA), Spain and Belgium.
- **The new space economy creates new markets and opportunities for SMEs to produce and operate micro-launchers, micro-satellites, and CubeSats**. Unlike SMEs in the traditional space, which either act as (exclusive) suppliers of the large players or are somewhat controlled by them, most of these recent companies are independent SMEs.
- **The space industry has seen a significant increase in the involvement of SMEs due to technological advancements, reduced technology costs, and increased accessibility to space, especially with the new space economy**. SMEs provide supply chain support by (i) providing specialised materials, components, and services; (ii) performing specific R&D activities; (iii) acquiring in-depth knowledge of client's needs; (iv) leveraging the data and capabilities of satellites to address various societal and OSA needs, ranging from environmental monitoring to telecommunications.
- **Barriers limiting access to the market and the full exploitation of SMEs' roles exist and can jeopardise the OSA goals**. They include the dominance of large companies with established client relationships, difficulties in sourcing critical components because of supply chain constraints, difficulties safeguarding their intellectual property against infringement or unauthorised use by competitors, and heavy regulation with strict licensing requirements and safety standards imposed by national and international authorities.
- **Recommendations** to pursue EU strategic posture and autonomy in the space systems technologies can be grouped under the following headlines: (i) create a more favourable procurement policy at the European and national levels for SMEs; (ii) enhance opportunities for SMEs to access specific technologies/components/materials; (iii) make public funding supports less prescriptive, more open and more integrated; (iv) support the private equity market, especially to secure funding to the SMEs in the new space economy; (v) protecting technology through IP rights to help SMEs secure a competitive edge, attract investment, and create new revenue streams; (vi) raise SMEs' awareness about available investment opportunities and facilitate the exchange of best practices. The recommendations are further elaborated in the chapter.

7.2.1 Overview of the value chain, positioning of SMEs and strategic vulnerabilities

This section still focuses on the aerospace and defence (A&D) ecosystem, but differently from the previous section, the link between OSA and SME development is examined considering **space launchers and satellites.** Launchers are required to put satellites in orbit; therefore, the two technical systems can be merged into the overarching technological category of "**space systems**". They are very complex systems integrating hundreds of parts and components, which require a wide variety of raw and processed materials for construction.

The competitors of the EU in this field are, at the same time, the main spacefaring countries and the suppliers of critical and strategic (raw) materials for space systems (see Section 7.2.1). Indeed, the EU is a space power with significant industrial capabilities and know-how, particularly regarding the assembly and integration of systems, i.e., the last stages of the value chain. Here, large European prime contractors mainly carry out the design and integration of the large space system. At the same time, SMEs contribute by bringing expertise (manufacturing of specific components), innovation (by engaging in the development of new technology), and services, such as support services for launch operations and ground segment infrastructure (see below). In contrast, the European space systems show vulnerabilities in (critical) raw materials, which are among the first building blocks of the industrial value chain.

Countries have always used space to demonstrate their sovereignty, power and technological advance. From 3 space-launching countries (the USSR, the US, and France) and three additional countries that owned satellites (Canada, United Kingdom, and Italy) in 1966, more than 65 countries are involved in space activities today. However, only a few of these (mainly the US, China, Russia, Western Europe, Japan and India) have the industrial and technical capacity to manufacture their satellites and launchers and operate the on-ground tracking, telemetry and control (TT&C) systems to monitor and guide their spacecraft.[491] In addition to power and technology-related issues, the return of the geopolitical dimension in the space sector is illustrated by the growing ambitions of spacefaring countries on the commercial space markets, which is the case of the US, China and, to a lesser extent, Russia and India. On top of that, both the COVID crisis and Russia's invasion of Ukraine negatively impacted the European space sector during recent years and continue to threaten the security of supply for materials and components.

The supply chain bottlenecks of space launchers and satellites can be analysed according to the five production process steps (raw materials, processed materials, components, assemblies, and super-assemblies). The JRC report "*Supply chain analysis and material demand forecast in strategic technologies and sectors in the EU – A foresight study. 2023*"[492] has already analysed each step in detail; however, it is worth summarising the main takeaways here. Considering the critical raw and processed materials, the most crucial concentration of critical constituents is from using specific metallic alloys, including ceramics and glass. Here, the dependency is on the original raw materials and mining countries, including China, the US, Japan, India, and so on. Among the key components, there are (i) solar cells for PV systems (Section 10.2), (ii) electrical, electronic and electromechanical components (Section 9.3), and semiconductors (Section 4.1) for space applications. Thrusters and engine-related components are key technologies ensuring the propulsion of launch systems and in-orbit payload positioning. Propulsion systems may face supply disruption mainly due to the significant market shares of Russian and US-based companies (e.g. EDB Fakel in Russia),

[491] Joint Research Centre (JRC) (2023) . Supply chain analysis and material demand forecast in strategic technologies and sectors in the EU – A foresight study. Available at https://publications.jrc.ec.europa.eu/repository/handle/JRC132889

[492] *Ibidem*

even if substitution with devices from other EU-based companies or EU competitors seems feasible (see Section 8.2.3)

Regarding assemblies, the space systems require lithium-ion batteries for power storage and supply (Section 6.1). At the same time, many other elements are critical in terms of European strategic autonomy and the enhancement of its industrial capabilities for the coming decades. They include gyroscopes and inertial measurement units,[493] (large-) antennas mainly supplied by the US even if the EU is making quick steps forward, providing quite similar technologies,[494] and CPUs (Central Processus Units), primarily imported from the US. When looking at current launching capabilities, the situation can be considered particularly critical for Europe, which lost access to the Russian-manufactured Soyuz launcher after the invasion of Ukraine in February 2022. Due to this disruption, the share of launches performed by EU commercial company Arianespace dropped dramatically. On top of that, the recent failure of the new Vega-C launcher in December 2022 and the delayed transition between Ariane 5 and Ariane 6 have jeopardised Europe's independent access to space and its associated strategic autonomy.[495]

7.2.1.1 The role of SMEs in the value chain

Analyzing the space value chain from the production process perspective analysed above helped identify strategic vulnerabilities. In contrast, looking at the market segments of the value chain allows us to better capture the role of SMEs.

The space value chain can be split into three main segments:[496]

- **This section focuses on the upstream segment.** It includes all the actors leading to an operational space system, i.e., all stages before the exploitation of space. The space industry in this segment designs, develops and manufactures spacecraft and launchers, along with the associated ground systems for satellite control and operations. As mentioned above, the segment is organised around large system integrators who specialise in bringing together components and subsystems as a whole and ensuring those subsystems function together once they are on the launch pad. These parts and components can be developed internally or by subsidiary/joint-venture companies, while others are directly imported from third countries.
- The midstream segment includes all actors involved in operating satellites and leasing or selling satellite capacity or data and all actors involved in manufacturing the ground support infrastructure and services required to exploit a space system (e.g. data storage and processing centres, network stations and equipment). This includes satellite operators, manufacturers of ground support infrastructures, and network equipment.
- The downstream segment comprises all actors providing space-related products and services to end-users. This includes service providers of broadcasting and broadband services, Earth Observation/ remote sensing value-added services, GNSS equipment, and satellite phones.

---

[493] European Space Agency (ESA), 'Ireland helping ESA's Hera asteroid mission find its way', 2020. (https://www.esa.int/Space_Safety/Hera/Ireland_helping_ESA_s_Hera_asteroid_mission_find_its_way)

[494] ESA. EDA and Commission (2020), EDA, 'Critical Space technologies for European Strategic non-Dependence - Action 2021-2023', 18 Feb 2020. https://a3space.org/wp-content/uploads/2020/02/JTF-List-of-Actions-for-2021-2023.pdf

[495] Hollinger P., 'Europe's independent access to space is at risk, says space agency chief', In: Financial Times, 9 Jan 2023. https://www.ft.com/content/14b060df-4cfc-4494-a3d2-2af57dc6fa2a

[496] It is not the only way to split and analyse the space supply chain. See for an excellent discussion the report "EU Space economics in the global context" , Final report, prepared by SpaceTec, CSIL, ESPI, Euroconsul, FDC in 2020.

The so-called space technology market segmentation comprises the upstream and midstream segments, including orbit, launch platform, launch vehicle, and payload (Box 32).

The European space technology market counts about 50,000 employees. It is rather concentrated, with four industrial groups (Airbus, Thales, and Safran in France, and Leonardo in Italy) directly responsible for more than half of total industry employment. Smaller but sizeable (mid-caps) space players such as GMV, RUAG and OHB provide additional employment and capabilities to the European space industry. Despite being distributed across all the European Space Agency member states, the leading industrial sites are in France, Germany, Italy and, to a lesser extent, the UK (as a full member of the ESA), Spain and Belgium.

About 400-500 SMEs contribute to the European space supply with a workforce of about 4,000 to 6,000 (10%) of the total employment, including microenterprises with less than ten employees. Only a few SMEs are 'pure' space players. At the same time, most comprise aerospace businesses operating in different ecosystems (automotive, health, defence and security, digital public services)[497] to offer customised solutions to different needs. Most SMEs are located in France, Germany and Italy, close to the large industrial groups.

Box 32: The global space technology market

This market segment is worth USD 294 billion globally in 2022 in terms of revenues, with North America having the lion's share (USD 134 billion), followed by Europe (about USD 95 billion) and the Asia Pacific area (USD 65 billion).

More specifically, the North American market is expected to dominate for years to come because of an increase in the variety of space missions, an increase in the government's funding for space exploration activities, and strategic cooperation between the main players to advance technological development. For instance, Boeing and Intel are collaborating strategically to advance semiconductor technology across the aerospace sector to develop next-generation microelectronics applications in artificial intelligence, secure computing, and advanced flight capabilities for future products.

The increasing number of partnerships and agreements between major market players and segments are also driving the growth of the European market. For instance, looking at the market from the end-user perspective, the commercial segment accounted for a major market share (45%) due to a rise in the number of satellites being launched. The remaining 55% is equally split between civil and military use.[498]

The Asia Pacific area is expected to grow exponentially over the next five years, surpassing Europe by 2030. The growth in demand for space launchers for satellite communications, telecommunications, and surveillance systems in the area will drive such an expansion. Moreover, China's Space Technology market held the largest market share, and the Indian Space Technology market has been the fastest-growing market in the Asia-Pacific region in recent years.

[497] Lionnet, P. (2021). The current structures of the European space manufacturing sector [online]. ASD Eurospace [online]. Available at: https://eurospace.org/analysis-current-structures-of-the-european-space-manufacturing-industry/.

[498] Mondor Intelligence (2023). Europe Satellite Manufacturing and Launch Systems Market Size & Share Analysis - Growth Trends & Forecasts (2024 - 2029) available a: https://www.mordorintelligence.com/industry-reports/europe-satellite-manufacturing-and-launch-systems-market

Source: Authors' elaboration based on Market Research Future (2024). Space Technology Market Research Report Information By Subsystem (Orbit, Launch Platform, Launch Vehicle, and Payload), By End-Use (Civil, Commercial, and Military), And By Region (North America, Europe, Asia-Pacific, And Rest Of The World) –Market Forecast Till 2032 Available at https://www.marketresearchfuture.com/reports/space-technology-market-8397?utm_term=&utm_campaign=&utm_source=adwords&utm_medium=ppc&hsa_acc=2893753364&hsa_cam=20513279457&hsa_grp=153141660637&hsa_ad=672796300975&hsa_src=g&hsa_tgt=dsa-2188716110822&hsa_kw=&hsa_mt=&hsa_net=adwords&hsa_ver=3&gad_source=1

European SMEs play several essential roles in the space technology market, particularly in the upstream segment. While traditionally dominated by large corporations and government agencies, the space industry has seen a significant increase in the involvement of SMEs due to technological advancements, reduced technology costs, and increased accessibility to space, especially with the new space economy. More specifically:

- **SMEs provide supply chain support**, providing specialised materials, components, and services to larger companies and government agencies. They ensure the availability of resources and expertise needed for the manufacturing and operation of the space systems.
- **SMEs and mid-caps in this segment frequently engage in R&D activities, which can lead to the emergence of space technology spin-offs also operating for other sectors and favouring cross-fertilisation** between ecosystems and technological advancement across various industries. SMEs develop new technologies, materials, and processes that improve space launchers and satellites' performance, reliability, and cost-effectiveness. More importantly, these activities often lead to the emergence of space technology spin-offs, which offer technology solutions in fields such as healthcare, transportation, energy, and telecommunications. This is the case of GMV, OHB, and RUAG, to mention a few.
- Closely to the point above, **SMEs are more able** (compared to large groups) **to acquire in-depth knowledge of clients' needs,** offer them the best solution fully adapted to their requirements and include all support necessary to achieve optimum results at a fair price thanks to their smaller size and flexibility. For instance, when involved in system integration and assembling various components and subsystems, SMEs work closely with larger aerospace companies and government agencies to ensure that the final product meets all specifications.
- Especially in the new space economy, **some European SMEs provide launch services, offering smaller, more cost-effective launch vehicles to deploy satellites into orbit to various clients**, including research organisations. The emergence of the private spaceflight industry and miniaturised satellites, launchers, and CubeSats have caused a radical change in traditional boundaries and business models. A few tens of companies have emerged in Europe in this market. Some are turnkey and fully integrated system suppliers; others are equipment/subsystem suppliers addressing this specific segment of small and micro space systems. A few entrant SMEs have grown to respectable sizes up to or more than 100 employees, such as GOM Space, ISIS, Mynaric, IceEye, Nanoavionics, Isar, RFA, etc. Unlike SMEs in the traditional space, which either act as (exclusive) suppliers of the large players or are somewhat controlled by them, most of these recent companies are independent SMEs.
- As regards the adoption of space products, SMEs develop and operate satellite-based services such as Earth observation, communications, and navigation. These services **leverage the data and capabilities of satellites to address various societal and OSA needs**, ranging from environmental monitoring to telecommunications.

7.2.1.2 Barriers for SMEs

Despite the potential of European SMEs in the space technological market, their role is still underexploited because of barriers to entry.

Access to the market is limited. The traditional space market is dominated by a few large companies with established relationships with clients (e.g., government agencies) and long-established relationships with trusted suppliers. Breaking into this market and securing contracts can be challenging for SMEs without a track record or established reputation. Another critical element to consider, as mentioned above, is that space activities are carried out by only a few space-faring countries with geopolitical interests, often with a mix of governmental policies and private space ventures. Therefore, the space industry, specifically launch activities and satellites manufacturing for the institutional domestic market segment (including civil and military applications), can be considered at least partly a captive market.[499] Data compiled from 2017-2019 suggests that only 60% of European launch contracts were issued following open market rules (PWC, 2020).[500] The share is much lower in extra-EU countries.[501]

SMEs encounter difficulties in sourcing critical components because of supply chain constraints. Most space-grade materials and qualified components are highly specific and require advanced manufacturing capabilities and technologies while relying on a global supply chain with long lead times and limited availability. This feature can increase the vulnerability of SMEs or deter their participation in this sector because the substitution of materials is not straightforward due to the stringent and time-consuming testing and qualification steps.

Space launchers and satellites involve highly complex technologies and engineering challenges. SMEs may lack the specialised expertise and resources needed to overcome these technical hurdles, particularly in areas such as propulsion systems, thermal management, and radiation hardening.

SMEs may struggle to safeguard their intellectual property (IP) against infringement or unauthorised use by competitors, particularly in international markets with varying legal frameworks. Space technology has long been one of the most advanced technical areas in the world. Still, it is only in recent years that IP issues have arisen in connection with extraterrestrial activities. One of the reasons for this is the exponential growth of commercial space, with activities increasingly shifting from state-owned to private and commercial activities.[502]

The space industry is heavily regulated, with strict licensing requirements and safety standards imposed by national and international authorities. SMEs may find it challenging to navigate these regulatory frameworks and ensure compliance, especially when seeking to launch satellites into orbit.

7.2.2 OSA goals and overview of relevant policy initiatives

The two leading players in the field of funding for space research and space technologies are the EC and the European Space Agency (ESA). Both have developed a range of technology support programmes that foster R&D and innovation at different levels of TRL. Moreover, each

---

[499] Joint Research Centre (JRC) (2023) . Supply chain analysis and material demand forecast in strategic technologies and sectors in the EU – A foresight study. Available at https://publications.jrc.ec.europa.eu/repository/handle/JRC132889

[500] The share is much lower in ex-tra EU countries, where restricted/captive markets rules are mainly applied to the 73% of the launch contracts in Japan, 77% in the US, 79% in Russia, 87% in India and more than 99% in China.

[501] The share is much lower in ex-tra EU countries, where restricted/captive markets rules are mainly applied to the 73% of the launch contracts in Japan, 77% in the US, 79% in Russia, 87% in India and more than 99% in China.

[502] Space Foundation (2022). The Role Of Intellectual Property In Space Innovation. Report available at https://www.thespacereport.org/resources/the-role-of-intellectual-property-in-space-innovation/

Member State has its instruments at the national or regional level. These are complemented by private financiers, who make funding available through equity, debt or hybrid products.

The EC is taking action to defend its interests, deter hostile activities in space and strengthen its strategic posture and autonomy. On 10 March 2023, the High Representative and the Commission presented a Joint Communication on an EU Space Strategy for Security and Defence for the first time to enhance the resilience and protection of space systems and services in the Union. The strategy was mainly based on three pillars: (i) "Potential EU Space Law" aiming at ensuring safety, security, and sustainability; (ii) "EU Space Information Sharing and Analysis Centre"; (iii) "Developing technologies and capabilities to increase resilience" (Table 10). Among others, the third pillar foresees synergies between available tools to support innovation, such as the European Defence Fund (EDF), the EU Space Programme, Horizon Europe (HE) and other relevant programmes. Indeed, interviews highlighted that existing funds have separate governance and operate as "silos" without any synergy preventing to exploit the full potential of innovation projects. The lack of synergy occurs for funds targeting the same ecosystem (e.g., the EDF and Cassini, see below) or sharing the same goal of spurring R&D (e.g., EDF or Cassini and HE). Interviews also noted that sometimes synergies materialise in practice, even if not foreseen in the design of the funds. For instance, there were cases in which spinoffs that received funding from HE with technology applicable to space also received funding from Cassini to develop their projects further and make them marketable.

Table 10. European Union Space Strategy for Security and Defence

Potential EU Space Law	EU Space Information Sharing and Analysis Centre	Developing technologies and capabilities to increase resilience
Enhance the level of security and resilience of space operations and services in the EU, as well as their safety and sustainability	Facilitated by the EU Space Programme Agency (EUSPA), gather information on incidents from commercial and public entities	Roadmap to reduce strategic dependencies on technologies that are critical for space (2024)
Encourage the development of resilience measures in the EU	Raise awareness and facilitate the exchange of best practices to build the resilience of EU space industry	Synergies between the European Defence Fund, the EU Space The programme, the Union Security Connectivity Programme (IRIS²), Horizon Europe and other relevant programmes
Foster information-exchange on incidents, as well as cross-border coordination and cooperation		Ensure that EU initiatives, including the Chips Act, the Critical Raw Materials Act, as well as possibly alliances and Important Projects of Common European Interest strengthen security of supply and the the resilience of space systems and services

Source: Authors based on the European Union Space Strategy for Security and Defence

ESA has several programmes and activities that are of interest to SMEs. For instance, it has a procurement policy on fair access for SMEs – known as "the C1-C4 clauses"- applied for certain types of procurement and are part of the structural measures within ESA's SME initiative. These two clauses aim to foster the competitiveness of equipment suppliers and SMEs (for C1 Clause) and of SMEs and Research Institutes (for C3 Clause) in areas where the concerned organizations have recognised expertise and capabilities. [503] Moreover, a few programmes, such as the Science Core Technology Programme (CTP) and the Basic Technological Development Programme (TDE), complement each other. Indeed, whilst the

[503] See ESA procurement policy https://www.esa.int/About_Us/Business_with_ESA/Small_and_Medium_Sized_Enterprises/Procurement_policy_on_fair_access_for_SMEs_-_the_C1-C4_Clauses Last access on 15/03/2024.

initial stages of new technology development, leading up to experimental verification, are pursued through TDE, the CTP exists to take these new technologies and apply them to the specific technical requirements of future science missions. Instead, permanent open calls targeted at new ESA MS facilitate their industry's access to the space value chain to smaller and new countries. Additional details and ESA programs and initiatives are reported in Table 11. The list is not exhaustive, and not all activities are targeted exclusively at SMEs.

Table 11. ESA programmes and activities of interest to SMEs[504]

Programme/Initiative	**EU Space Information Sharing and Analysis Centre**
Procurement actions reserved for SME and "Non-Primes" (C1-C4 clauses)	To guarantee fair access to its programmes for all categories of companies, ESA has designed and implemented a set of clauses, known as the 'C1–C4 clauses', which are applied for certain types of procurement (see the primary test for details).
Technology Development Element Programme (TDE)	The Technology Development Element (TDE) is responsible for early development stages across all ESA service and technology domains, taking cutting-edge ideas and testing their suitability for space applications. It focuses on Technology Readiness Levels (TRL) 1-4. TDE is a mandatory programme. It is the only ESA technology programme supporting all of ESA's fields of activity across the entire spectrum of technical disciplines, providing the technological nucleus for most future developments.
Science Core Technology Programme (CTP)	The mandatory Science Core Technology Programme (CTP) is integral to the Science Programme. Its objective is to ensure early and effective preparation of ESA's future science missions by preparation of the critical enabling technologies required for successful mission development. CTP-funded activity carries them to higher stages of technological maturity, up to full-scale engineering models fully tested in relevant environmental conditions, and ready for inclusion in the definition stage of the mission, which is the design phase that guides the actual spacecraft construction.
ESA ARTES 4.0 Programme, including ARTES Core Competitiveness and BASS (Business Applications and Space Solutions)	The Advanced Research in Telecommunications Systems (ARTES) 4.0 programme enables European and Canadian industry to explore, through research and development (R&D) activities, innovative concepts to produce leading-edge satcom products and services. ARTES 4.0 offers varying degrees of support to projects with different operational and commercial maturity levels. The scope and plans for its pursuit are incorporated into the Telecommunications Long-Term Plan (TLTP), the blueprint for ESA's actions over five years. The programme also provides multi-disciplinary expertise and business knowledge to SMEs and international consortia. ARTES is divided into several lines of action, each one with specific objectives,
Boost! - Commercial Space Transportation Services and Support Programme	To boost commercial initiatives that offer space transportation services to space, in space, and returning from space supports ESA Member States in implementing national space transportation objectives in spaceports, testing facilities and associated services.
Permanently Open Calls for New Member States (NMS)	ESA administers Permanently Open and Down Announcements of Opportunity for Outline Proposals under the Industry Incentive Schemes of Estonia, Hungary and Romania. Companies are invited to submit an outline proposal under the ongoing calls in esa-star Publication.
Technology Transfer and Patents	ESA administers Permanently Open and Top Down Announcements of Opportunity for Outline Proposals under the Industry Incentive Schemes of Estonia, Hungary and Romania. Companies are invited to submit an outline proposal under the ongoing calls in ESA-star Publication

Authors based on the ESA website.
https://www.esa.int/About_Us/Business_with_ESA/Small_and_Medium_Sized_Enterprises/ESA_programmes_and_activities_of_interest_to_SMEs#TDE

504 ESA website: https://www.esa.int/About_Us/Business_with_ESA/Small_and_Medium_Sized_Enterprises/ESA_programmes_and_activities_of_interest_to_SMEs#TDE

Box 33: SMEs dedicated activities from other space agencies.

The NASA Office of Small Business Programs aims to promote and integrate small businesses into the industrial base of its contractors and subcontractors. To this end, SMEs can (among others): (i) explore subcontracting opportunities through several services, including solicitations and notices posted by prime contractors;[505] (ii) investigate NASA Small Business Programs such as the the NASA MentorProtégé Program, or the Small Business Innovation Research Program among others,[506] (iii) seek assistance as needed, including request training and counselling on marketing, financial, and contracting issues at minimal or no cost from Procurement Technical Assistance Center (PACTs). PTACs are located in most states and are partially funded by the U.S. Department of Defense (DOD) to provide small business concerns with information on how to do business with DOD and other Government agencies.[507]

JAXA, the Japanese National Space Agency, collaborates with private companies, including SME operating in different business areas to help promote the space industry. The space innovation partnership called J-SPARC launched in 2018 facilitates private businesses with ideas on space business to join forces with JAXA by bringing together human resources and funds with the ultimate goal of creating new concepts, from the time of the planning stage. J-SPARC is an open innovation program based on a system of partnership, where necessary technological developments and verifications are conducted with the aim of giving birth to new business opportunities.

Authors based on NASA's Office of Small Business Programs (OSBP) website. (https://www.nasa.gov/osbp/mission-and-overview/) JAXA's Business Development and Industrial Relations Department (https://global.jaxa.jp/activity/pr/jaxas/no077/08.html)

In addition to HE (discussed in Section 7.1.3), the Commission's Cassini initiative is a relevant **European direct funding programme aiming to enhance innovation and industrial capacity of SMEs in the space sector.** It supports entrepreneurs, start-ups, and SMEs in the space industry, including New Space, from 2021 to 2027. Cassini is open to all areas of the EU Space Program and covers both upstream (i.e., nanosats, launchers, etc. and downstream (i.e. products/services enabled by space data, etc.). It has lines of actions dedicated to the following main areas: (i) access to finance through EUR 1 billion of its equity facility to support and facilitate access to finance to EU start-ups and SMEs involved in space-related endeavours; (ii) business development, accelerator, and networks through which the initiative supports a series of matchmaking events for start-ups and SMEs to expand their professional networks and find new product development partners, customers, and investors. Each event offers opportunities for industrial partnering with large corporations and matchmaking with investors. The events touch upon different business areas, follow a balanced geographic coverage throughout Europe with rotating events and address different value chains; (iii) Cassini - Prizes and Competitions that offer opportunities to share ideas in different business areas.[508]

At the national level, two recent examples of SME support in space are from France and Germany. In France, the European Investment Fund (EIF) and the French Centre National d'Études Spatiales (CNES) signed a cooperation agreement in June 2022 to support SMEs in

[505] See for details: http://web.sba.gov/subnet/search/index.cfm http://www.sba.gov/category/navigation-structure/contracting/contracting-opportunities/sub-contracting/subcontracting-opportunities-directory

[506] See for details http://osbp.nasa.gov/mpp/index.html ; http://sbir.gsfc.nasa.gov ; http://osbp.nasa.gov

[507] http://www.dla.mil/HQ/SmallBusiness/PTAC.aspx

[508] For details see CASSINI Initiative. Available at https://defence-industry-space.ec.europa.eu/eu-space/entrepreneurship_en

the space sector. The partnership is part of the CNES' objectives and performance contract, under which the CNES is responsible for strengthening the competitiveness of the French space sector by supporting the diversification of players in the ecosystem, focusing on the development of disruptive technologies and implementing new partnership models and co-investing with the industry. It supports transitioning from an infrastructure economy to a data-driven economy, promoting new uses and services. [509] In Germany, a dedicated portal (www.best-of-space.de) allows German space SMEs to present their competencies, products and services for the global space market. The portal is open for the inclusion of further companies. Space startups can also present themselves since cooperation between established SMEs and young entrepreneurs is desirable and expedient in rapid innovation.

7.2.3 Recommendations for future policy actions

The EU leaders have identified space as a strategic domain in the Strategic Compass, giving the European Union an ambitious plan of action to strengthen the EU's security and defence policy by 2030.[510] As mentioned in the previous section, the EU is taking action to defend its interests; however, enhancing European resilience in this sector requires target initiatives for SMEs to unleash their full potential and reduce the barriers they face.

Create a more favourable procurement policy at the European and national levels for SMEs to compete and thrive in the market of space launchers and satellites. Three practical actions can be envisaged:

- Set aside contracts for SMEs by reserving a certain percentage of procurement contracts for SMEs. This will increase opportunities to participate in government-funded projects and compete for contracts alongside larger firms. The introduction of this practice is not new, and it seems feasible, as proved by the ESA's procurement policy on fair access for SMEs ("the C1-C4 clauses"), the EIC under the HE (see Section 7.1.3), and the dedicated office for small business in the case of NASA.
- Simplify the procurement procedure by streamlining procurement processes to reduce administrative burdens and make it easier for SMEs to navigate and participate. For instance, standardised contract terms and conditions (bidding requirements) could be envisaged at least among the main public buyers (European Union, ESA, and the national space agencies in the most relevant MS), each of which has its dedicated legal frameworks and procedures.[511] In addition, assistance and negotiations during the procurement process help SMEs reduce administrative burdens, according to interviews.
- Ensure fair competition and prevent anti-competitive behaviour in procurement processes. Even if the European public procurement market is much more open than global competitors, reducing barriers to entry for SMEs also calls for further increasing the share of contracts following open market rules beyond the current 60% (see Section 7.2.1.2).

Reducing EU dependencies on technologies that are critical for space may enhance opportunities for SMEs to access them. Two types of actions can be implemented.

[509] if.org/what_we_do/equity/news/2022/eif-and-centre-national-etudes-spatiales-sign-cooperation-agreement-to-support-smes-in-the-space-sector.htm

[510] https://www.eeas.europa.eu/eeas/strategic-compass-security-and-defence-1_en

[511] Baumann, I., Mey, J. H., & Pellander, E. (2023). Industry and Agency Contracts and Procurement: A European Perspective. In Oxford Research Encyclopedia of Planetary Science. https://doi.org/10.1093/acrefore/9780190647926.013.180

- Substituting devices from extra-EU competitors with European-made devises, where possible. Propulsion systems are subject to supply disruption mainly due to the significant market shares of Russian and US-based companies. Substitution with devices from other competitors seems feasible at the EU level. Safran is well positioned (supplying Gallileo's new generation of electric propulsion devices)[512] or dynamic start-ups such as ThrustMe and Exotrail.[513] Additional examples include chips, specifically CPUs, primarily imported from the USA. Some European initiatives include the development of LEON processors under ESA leadership, which seek to ensure reliability and radiation-hardening properties [514] . At the same time, in January 2023, the first EU space-qualified programmable chips, known as field-programmable gate array (FPGA), was presented by the company NanoXplore and is considered a promising way to reduce EU technology dependencies.

- Stockpiling of strategic, durable, non-perishable materials/components. When considering cross-sectorial competition against more conventional sectors, one advantage of the space sector stems from its high "willingness to pay" premiums to supply specific materials and components. Therefore, the stockpiling of strategic materials/components is feasible for the space industry, which has not adopted the "just-in-time" manufacturing structure of sectors such as automotive and electronics. This would help reduce supply chain constraints SMEs encounter when sourcing critical components.

Making public funding supports less prescriptive, more open and more integrated. Synergies between EU public funding programs in Space, Defence (e.g. the EDF), Horizon Europe (HE) and other relevant programmes are also needed to promote cross-fertilisation between the space and non-space sectors.[515] Firms operating in the space sector, including SMEs, often have space and defence divisions, which cross-fertilise between them with the exchange of expertise and technology by leveraging their competitive advantage. Instead of being thought of as silos, existing funding programs in defence and space could foresee some mechanisms to exploit technology synergies (e.g., include eligibility criteria to award SMEs with the potential to exploit synergies in both sectors) or support firms along the technology development life cycle. For instance, access to HE to fund initial R&D with potential applications in other sectors (beyond space and defence) and then access to sector-specific funds to further develop the technology to fit dedicated requirements.

Support the private equity market, especially to secure funding for the SMEs in the new space economy. The space industry has witnessed a tremendous commercialization wave. Numerous start-up companies are emerging in the European leading space nations and non-traditional space countries. These companies are being offered the opportunity to attract private investments as never before. However, the capital markets, through the traditional channels (bank loans), generally do not supply the necessary funding, creating a funding gap in the market, a situation that several governments around the globe and in the EU are trying to address.[516] Injection of public funds through financial institutions such as the EIF or the EIB

---

512 https://www.safran-group.com/companies/safran-spacecraft-propulsion

513 https://www.safran-group.com/companies/safran-spacecraft-propulsion; https://www.thrustme.fr/ ; https://www.exotrail.com/
Joint Research Centre (JRC) (2023) . Supply chain analysis and material demand forecast in strategic technologies and sectors in the EU – A foresight study. Available at https://publications.jrc.ec.europa.eu/repository/handle/JRC132889

514 CAES, 'CAES announces Space Grade Qualification of Quad Core LEON4FT Microprocessor', In: Accesswire website, 9 June 2022. https://www.businesswire.com/news/home/20220609005670/en/CAES-announces-Space-Grade-Qualification-of-Quad-Core-LEON4FT-Microprocessor

515 For instance, the Union Security Connectivity Programme (IRIS²). https://defence-industry-space.ec.europa.eu/eu-space-policy/iris2_en Last access on 15/03/2024

516 The annual gap of equity risk capital in the European space industry is between EUR 0.9 billion and 1.6 billion. See EC and EIB (2020). The future of the European space sector. How to leverage Europe's technological leadership and boost investments for space ventures. Available at https://www.eib.org/en/publications/the-future-of-the-european-space-sector-executive-summary

can help develop the venture and private equity market timely, while giving the opportunity to start-ups accessing large amounts of capital through specialised funds, particularly during the scale-up phase.[517]

Protecting technology through IP rights to help SMEs secure a competitive edge, attract investment, and create new revenue streams. Differently from the past when governments and public agencies dominated the space sector**,** in the future, technical and financial input from the private sector will become increasingly important for developing space activities. This poses challenges for the IP application to space technologies, at least from two perspectives. First, IP protection is subject to the principle of territoriality, and the country where the space Invention/object is registered retains jurisdiction and control over that space invention/object, according to the international space law. However, there are still open issues if the territorial jurisdiction under IP law permits the extension to outer space. Indeed, in the absence of explicit international rules and according to several international agreements on collaborative space programs, registered space inventions/objects are treated as quasi-territory for IP. Second, the exploration and use of outer space for the benefit of humanity and the non-appropriation of outer space by any nation are fundamental principles under international space law.[518] While IP and innovation are paramount for exploring outer space and further developing science and technology, questions have been raised about whether protecting and enforcing IP rights may conflict with these fundamental principles.[519] Like almost every other innovation, space-related inventions could benefit from protection from the following main IPRs: (i) patents when they qualify; (ii) utility models, where available, could also apply to minor inventions; (iii) the inventor can trademark the creations' names and related logos (think of Elon Musk's company); (iv) trade secrets can probably play an essential role in protecting important advancements and confidential business information in this field. More importantly, seeking international protection in multiple countries is crucial as the space sector operates globally. Although not space-specific, the Patent Cooperation Treaty (PCT) facilitates patent protection in numerous countries through a single application.

Raise SMEs' awareness about available investment opportunities and facilitate the exchange of best practices. This recommendation echoes the one already discussed under the robotics and drones application in defence. SMEs' awareness about market needs can be raised via matchmaking initiatives for investors, A&D SMEs, business associations, and policymakers. According to interviews, the Cassini Initiative already provides similar tools, but more can be done. For instance, a Pan-European online platform to support local stakeholders (business associations) and SMEs involved in space systems technologies can be designed to exchange best practices and list the SMEs and specialised (private equity) funds active in the sector.

---

[517] Although the EU is fertile ground for scientific research, technology and innovation, European start-ups are struggling to reach the same maturity levels as their American counterparts. According to EC and EIB (2020) Europe had produced only 26 "unicorns" (i.e. start-up companies with a market valuation over USD 1 billion), compared with 109 in the US and 59 in China. A similar results was found in the Defence sector by EC (2024) report "Access To Equity Financing For European Defence SMEs" See https://defence-industry-space.ec.europa.eu/study-results-access-equity-financing-european-defence-smes-2024-01-11_en

[518] As prescribed in Articles I and II of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (Outer Space Treaty) (https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introouterspacetreaty.html)

[519] For a more detailed discussion see European Commission (2021) IP and Space Activities available at https://intellectual-property-helpdesk.ec.europa.eu/news-events/news/ip-and-space-activities-2021-04-29_en

8 OSA and SMEs in the agrifood ecosystem

The Common Agricultural Policy (CAP) was introduced in 1962 to ensure stable and affordable food supplies for EU citizens. This has been a central pillar of overall EU policy making since. Moreover, various shocks, in particular the COVID-19 pandemic, the war of aggression by Russia against Ukraine, climate change and rising costs of food products (which in turn caused overall inflation to spike) have renewed attention to these goals and underlined the important of realising strategic autonomy when it comes to the agri-food ecosystem.[520]

While **overall food security within the EU27 is relatively secure and the broad goals of the CAP are not at risk, there are a few areas where the EU27 is critically dependent on foreign suppliers**. Both chemical fertilisers, as well as high-protein crops for animal feeds stand out, and are therefore analysed in more depth below. In both cases the war against Ukraine have made longstanding dependencies even more pressing.

There is a direct link between both topics of interest. Rapeseeds, which are produced at scale as high-protein crops for animal feed, require substantial volumes of nitrogen-based fertilisers to have optimal yields. Strategies to raise the homegrown production of fertiliser may therefore have an impact on the market of high-protein crops. Because legumes have the ability to fix nitrogen, the requirement for synthetic nitrogen fertilisers is notably diminished for protein crops in comparison to other crops, resulting in decreased overall nitrogen fertiliser needs for the farm.[521] At the same time and apart from this observation, the value chains and policy applications are quite distinct and for this reason are handled in separate sections in this report.

8.1 Mineral fertilisers

8.1.1 Overview of the value chain, positioning of SMEs and strategic vulnerabilities

Highlights:

- SMEs are relatively absent in the immediate value chain of mineral fertilisers, primarily due to the capital-intensive nature of extraction, processing, and production phases.
- However, they play a significant role in niche segments such as the global bio stimulant industry, where they dominate research and development stages, particularly in Europe. Producers of organic-based fertilisers are often SMEs, benefiting from proximity to raw materials and end-users in rural areas.
- Precision farming techniques and sustainable farming practices, such as crop rotation and targeted fertiliser application, offer avenues to reduce reliance on imported fertilisers and involve SMEs in technology adoption and advisory services.
- The EU aims to decrease dependency on imported fertilisers through policy initiatives like the EU Fertilising Products Regulation, which provides a regulatory framework for the industry across EU member states.
- Recommendations include supporting organic farming practices, enhancing access to organic fertilisers, and promoting sustainable soil fertility management, all of which offer opportunities for SMEs.

520 https://www.europarl.europa.eu/RegData/etudes/BRIE/2023/739328/EPRS_BRI(2023)739328_EN.pdf

521 https://library.wur.nl/WebQuery/wurpubs/fulltext/262633

- The Integrated Nutrient Management Action Plan encourages efficient and sustainable fertiliser use, involving SMEs in consultancy services and end-user engagement.
- Policies like the Common Agricultural Policy (CAP) provide support and incentives for farmers, including SMEs, to adopt sustainable farming practices and efficient fertiliser use.

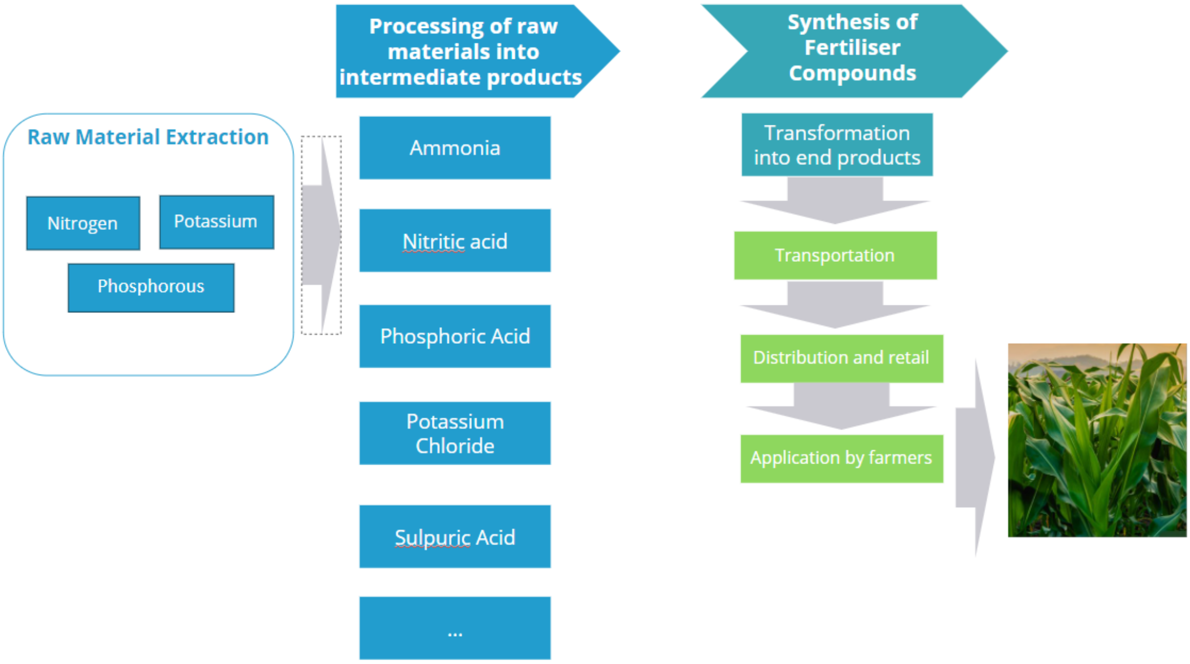
8.1.1.1 The value chain in some depth

Synthetically created fertilisers are essential to modern-era agriculture and, hence, play a significant role in food security. Their main purpose is to provide essential nutrients to crops, thereby increasing crop yields and correcting for crop deficiencies. They replenish nutrients in the soil that may have been depleted for various reasons. First, it is important to note that, broadly speaking, there are three types of mineral fertilisers:

- Nitrogen-based fertilisers containing nitrogen as the primary nutrient. Nitrogen is essential for plant growth and is often needed in large quantities. Examples of nitrogen-based fertilisers include urea, ammonium nitrate, and ammonium sulfate.
- Phosphorus-based fertilisers contain phosphorus, which is important for root development, flowering, and fruiting in plants. Examples of phosphorus-based fertilisers include superphosphate and triple superphosphate.
- Potassium-based fertilisers containing potassium, which helps regulate water uptake, nutrient movement, and enzyme activation in plants. Examples of potassium-based fertilisers include potassium chloride and potassium sulfate.

The fertiliser value chain is quite complex. The first step involves extracting raw materials, including natural resources like potash, phosphate rock, and natural gas. These are essential for producing the primary nutrients required in fertilisers: nitrogen (N), phosphorus (P), and potassium (K). As a second step, these raw materials are processed into intermediate products such as ammonia. This involves chemical processing methods such as the Haber-Bosch process. A third step consists of the creation of fertiliser compounds. For instance, ammonia is combined with nitric acid to make ammonium nitrate or carbon dioxide to make urea. These compounds are then made into various end products, single-nutrient or multi-nutrient, in different forms such as powders, granules or liquids. After packaging, the fertilisers are then transported (often over long distances) and sold to the end user by agricultural supply stores or cooperatives. A final step involves farmers' application of fertiliser.

Figure 33. The fertiliser value chain



Source: authors

8.1.1.2 The dependence of the EU

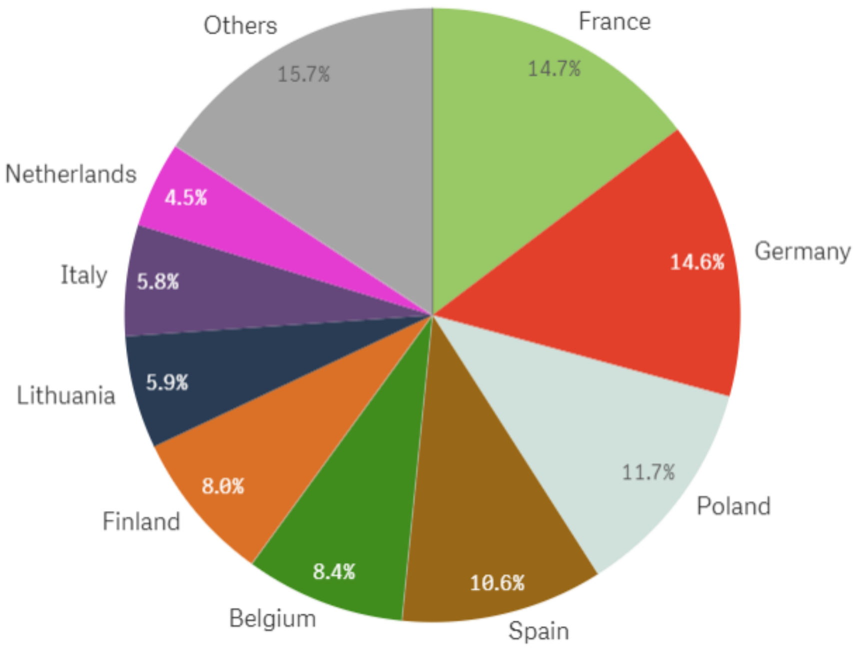
There are around 120 production sites across the EU27. In addition, they are **geographically dispersed, reflecting the business rationale of being close to end consumers** (see Figure 34).

Figure 34. Major Fertiliser plants in Europe

Source: https://www.fertilizerseurope.com/

The chart below indicates that fertiliser production by volume is relatively dispersed across the union, with smaller Member States such as Finland and Lithuania playing a relatively important role.

Figure 35. Fertiliser production in the EU27



Source: https://agridata.ec.europa.eu/extensions/DashboardFertiliser/FertiliserProduction.html, accessed on February 26

At the same time, the EU is not self-sufficient. The share of imported products of EU consumption stood at 35% for nitrogen-based fertiliser, 65% for phosphate fertiliser and 88% for potassium oxide fertiliser in 2021. The same year, Russia was the most important importer, followed by Egypt, Morocco and Belarus.

8.1.1.3 The role of EU SMEs in the value chain

It is important to note that the fertiliser value chain's extraction, processing and production phases are subject to economies of scale and involve heavy machinery. **This capital intensive nature implies that these activities, almost by nature, are conducted by very large enterprises with little direct involvement of SMEs.** The 120 production sites listed by FertilisersEurope are large firms, without any exception, and SMEs are relatively absent within the immediate value chain of mineral fertilisers.

However, the focus of the analysis will be on **certain segments or niches within the broader industry of nutrient management solutions where SMEs play a larger role.**

The global biostimulant industry is forecasted to equal USD 3.9 billion in 2023 and is projected to expand to USD 6.8 billion by 2028. In addition, Europe has a strong position, with around half of global activities taking place in the EU.[522] Spain, Italy, and France are the main markets within the EU in terms of the production and usage of biostimulants.[523] Interviews also indicate that **the market is relatively easy to contest with a sizeable presence of smaller businesses and start-ups**. This is confirmed by market data that show that, even though

---

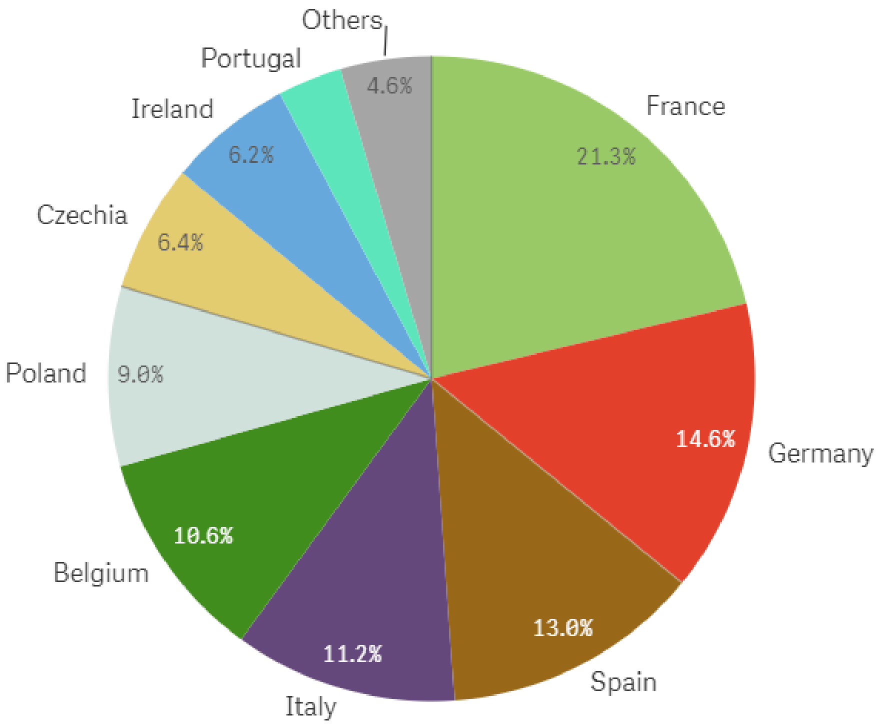
522 https://www.marketsandmarkets.com/Market-Reports/biostimulant-market-1081.html

523 https://www.marketsandmarkets.com/Market-Reports/biostimulant-market-1081.html

large companies have entered the market at the top line of the market by acquiring established technologies and end products, SMEs dominate at the research and development stages. In addition, many firms that have been active in the market for a relatively long period of time, both in production and development, are SMEs.[524]

In contrast to the mineral fertiliser market, producers of organic-based fertilisers are often small enterprises located in rural areas. This proximity to "raw materials" and end users is largely explained by the relative bulkiness of organic fertilisers, making them hard to transport over long distances (which is also distinct from inorganic-based fertilisers). Their research typically takes place in partnership with universities and independent research institutes.[525] The top five producers of animal and vegetable fertilisers, which largely coincide with organic fertilisers, consist of France, Germany, Spain, Italy and Belgium (see Figure 36). Biowaste processing is an industry with an annual turnover of between 1 and 2 billion euros and employs between 13.000 and 23.500 employees (in full-time equivalents).[526] According to interviewees, most of these companies are small or medium-sized, as economies of scale play a smaller role, and relatively modest facilities can be as productive as larger ones.

Figure 36. The production of animal and vegetable fertilisers in the EU27 by country, 2022



Source: https://agridata.ec.europa.eu/extensions/DashboardFertiliser/FertiliserProduction.html, accessed on 16 February 2024

Finally, precision farming and sustainable farming techniques are important avenues to limit the dependence on (imported) mineral fertilisers. FertilisersEurope estimates that the efficiency of nitrogen-based fertilisers currently stands at 40%, meaning that a lot of fertiliser is consumed without raising crop yields (in a manner that is damaging to the environment). While a level of 100% is not feasible for technical reasons, it should reportedly be possible to increase efficiency to 70%, indicating that the same output can be realised with a substantially lower use of fertilisers.

524 https://commodityinsights.spglobal.com/biostimulants-report-2022.html

525 https://www.ecofi.info/benefits-of-organic-based-fertilizers/fostering-vibrant-economies/

526 https://www.compostnetwork.info/wordpress/wp-content/uploads/ECN-rapport-2022.pdf

8.1.2 OSA goals and overview of relevant policy initiatives

At a meeting of the fertiliser market observatory in 2023, there was agreement among several member states that it would be helpful for the "*EU-based fertiliser production to decrease Europe's dependency from unreliable partner and supplies disruptions due to geopolitical issues.*[527] However, it is important to note that the availability of resources within the EU27 is limited, as the raw materials are mostly abundant outside of its borders. This, coupled with high prices for natural gas, puts a major constraint on increasing production capabilities within the EU.

There are several avenues to limit the dependence of the EU27 on imported fertilisers. One notable success has been the diversification of foreign suppliers away from Russia and Belarus in the aftermath of the Russo-Ukraine war.[528] In 2022, a communication from the European Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Region was issued. Titled "ensuring availability and affordability of fertilisers: Recommendations for future policy actions," it sets forward some broad action lines (see following Box 34).

Box 34: Selected recommendations to ensure the availability and affordability of fertilisers

- Help farmers use fertilisers more efficiently and sustainably.
- The amended Temporary Crisis Framework for State aid enables specific support to farmers and fertiliser producers.
- Reduce excess fertiliser use: The Farm to Fork Strategy has set a target to reduce nutrient losses by 50% by 2030, while preserving soil fertility.
- Better access to organic fertilisers and nutrients from recycled waste-streams, especially in regions with low usage of organic fertilisers.
- The adoption of an Integrated Nutrient Management Action Plan aiming at action at EU and national level to promote more efficient use of nutrients.
- Supporting the use of effective and sustainable farming practices and alternatives based on sustainable soil fertility management.
- Support for import diversification to reduce dependence on Russia.
- Prevent nutrient losses by 50% by 2030 while preserving soil fertility.

Source: https://eur-lex.europa.eu/resource.html?uri=cellar:c82d9dd0-61b9-11ed-92ed-01aa75ed71a1.0001.02/DOC_1&format=PDF

Four lines of action will be explored in more depth in this report, based on the recommendations of Box 34 and on the (potential) role that SMEs can play, as well as the

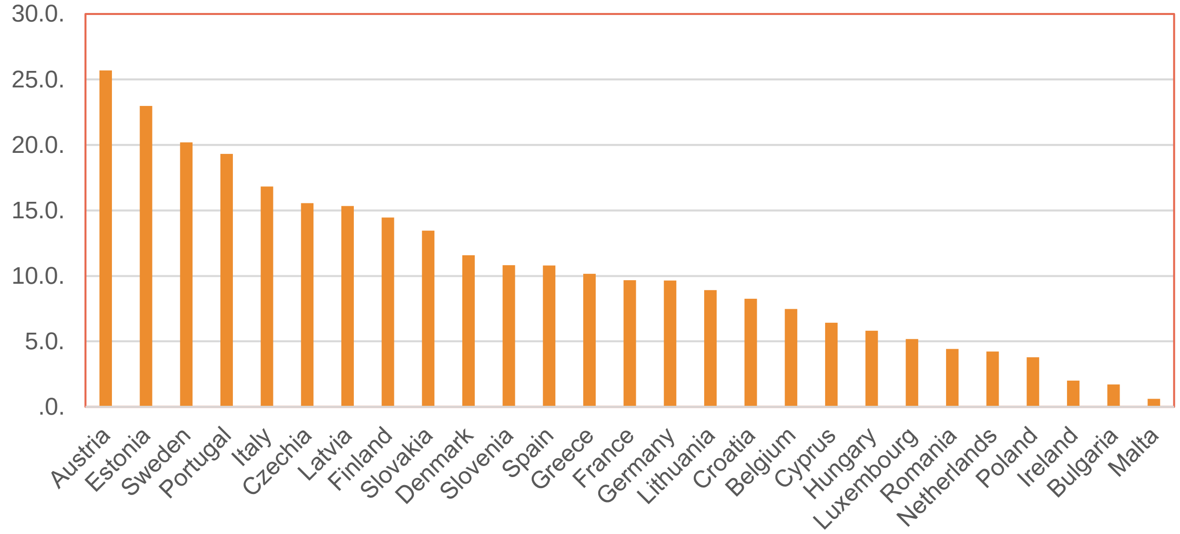
527 https://agriculture.ec.europa.eu/document/download/82516359-29f8-4f0a-8a1c-63f0a2a563d1_en?filename=fertilisers-mo-2023-11-24-report_en.pdf

528 https://agriculture.ec.europa.eu/document/download/ab0c0033-ff3f-4c97-a3e7-8f6ef0e79bd4_en?filename=fertilisers-mo-2023-06-27-report_en.pdf

general outlines of the EU Farm to Fork Strategy, which calls for a reduction of nutrient losses by at least 50 per cent and a reduction in the use of fertilisers by at least 20 per cent by 2030.[529]

First, **organic farmers, many of which are SMEs, use chemical fertilisers only as a last resort**. Evidence indicates that the fertiliser hectares of organic farms use is 50 to 90 percent lower than their non-organic counterparts. The same study suggests lower crop yields on average, but only at a magnitude of 5% to 30%.[530] The EU developed an action plan to raise the percentage in support of the target of at least 25% of the EU's agricultural land under organic farming, compared to the 9.9% that was reached in 2021.[531] At the same time, the huge dispersion across EU countries indicates ample room for lagging countries to catch up (see Figure 37 below).

Figure 37. The proportion of agricultural land (%) by organic farmers



Note: Data for Austria and Greece are from 2020 (as 2021 data were not available).
Source: Eurostat

Second, in 2019, the Fertilizer Regulation (EC) No 2019/1009 came into force. It aims to ensure the safety, quality, and effectiveness of fertilising products placed on the EU market while promoting innovation, sustainability, and market harmonisation.[532]

One novel feature was the introduction of a definition of plant biostimulants, describing them as products containing substances and/or microorganisms whose function is to stimulate plant nutrition processes independently of the product's nutrient content to improve one or more of the following characteristics of the plant or the plant rhizosphere:

- Nutrient use efficiency;
- Tolerance to abiotic stress;
- Crop quality traits.

This regulatory change reflects a growing interest in the biostimulant industry, which complements traditional fertilisers. While they are not fertilisers themselves (as they

529 https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en
530 Organic farming in the EU: a decade of growth - European Commission (europa.eu)
531 https://eur-lex.europa.eu/resource.html?uri=cellar:13dc912c-a1a5-11eb-b85c-01aa75ed71a1.0003.02/DOC_1&format=PDF
532 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R1009

typically do not contain significant amounts of primary nutrients like nitrogen, phosphorus, or potassium), they can complement fertilisation practices and improve nutrient use efficiency. Their wider take-up would, therefore, reduce the dependence on imported fertilisers and foster OSA in the agri-food business. In addition, the EU is at the forefront of the plant biostimulant industry, and SMEs play an essential role in various stages of the economic cycle, from production to R&D.

Third, **organic fertilisers** (not to be confused with organic farming) **represent a direct alternative towards chemical fertilisers**. Expanding its use would lower the dependence on imports and thus foster OSA. Also, this industry is less capital-intensive than the chemical fertilisers industry and thus involves more SMEs. Livestock manure is a longstanding fertiliser, but other organic materials such as food scraps, yard waste, and agricultural residues can be used as fertiliser through direct and indirect methods. Nutrient retrieval from algae and sewage sludge is in the pilot phase but could have commercially viable applications in the future.[533] The direct method involves composting and vermicomposting (using biological materials as fertilisers). The indirect method entails the transformation of the organic materials into chemical fertilisers through a process known as mineralisation or ammonification or the anaerobic digestion process of organic materials in biogas material. These end products resemble fertilisers produced from nitrogen, potassium or phosphorous and can thus be used similarly.

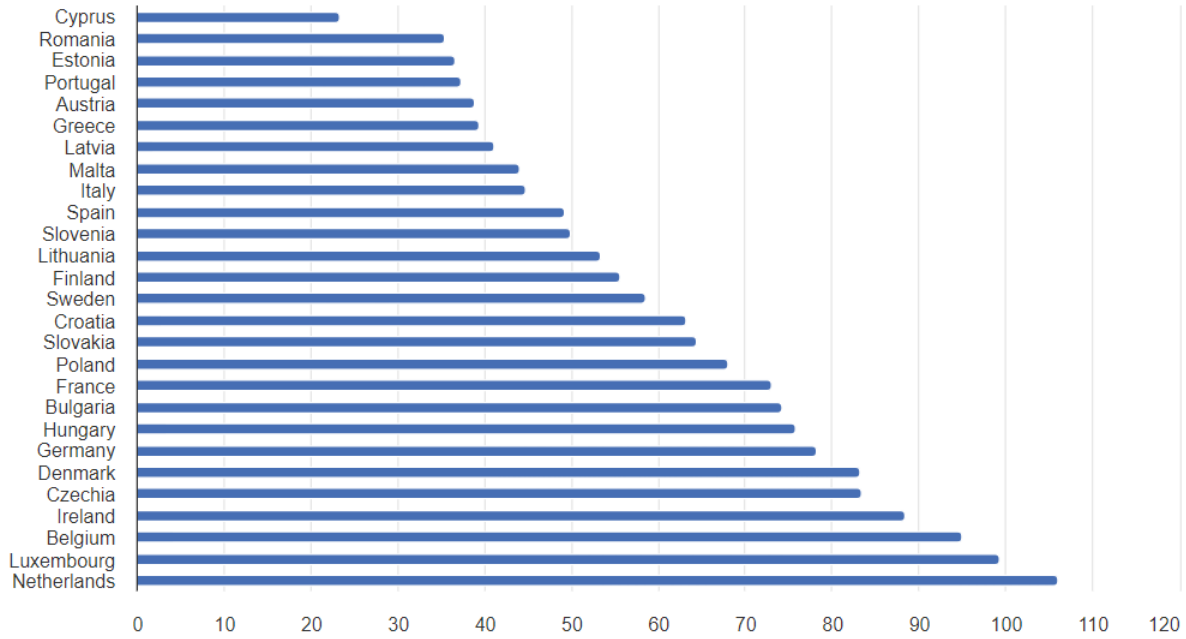
Fourth, any **policy initiatives to use fertilisers (both organic and inorganic) more efficiently, as currently under development by the Integrated Nutrient Management Action Plan, have the potential to reduce the need for imported fertiliser drastically**. Examples include enhanced fertilisation practices, such as using cover crops, choosing the appropriate type of fertiliser for the specific circumstances, and precision farming allowing optimised application of limited amounts of fertilisers.[534] In addition, these initiatives typically involve the end-users, some of whom are SMEs, and small businesses that provide consultancy services to the end users.[535] Data on the use of inorganic fertilisers, for example, based on nitrogen, indicate a wide dispersion of its use by Member State (adjusted for hectare of land used in agriculture). While the difference is due to various factors, especially the exact use of agricultural land, it indicates that there is scope to limit the use of fertilisers across the EU.

533 https://www.eesc.europa.eu/en/news-media/news/addressing-fertiliser-crisis-europe-actions-availability-affordability-and-sustainability

534 https://www.eesc.europa.eu/en/news-media/news/addressing-fertiliser-crisis-europe-actions-availability-affordability-and-sustainability

535 For example, Forigo is an Italian-based SME that, among other activity, provides support to farmers on how to use cover crops, which reduce the need for fertilisers.https://www.forigo.it/en/news/cover-crops-what-they-are-production-and-benefits

Figure 38. Average consumption of nitrogen-based fertilisers by kilo and per hectare of land used in agriculture, average between 2018-2020



Source: https://agriculture.ec.europa.eu/common-agricultural-policy/agri-food-supply-chain/ensuring-availability-and-affordability-fertilisers_en

It is interesting to note that other advanced countries around the globe are also taking actions to reduce the dependence on (imported) mineral fertilisers, often part of a broader strategy to "green" its agricultural practices. Box 35 provides information about the approach in Japan and South Korea.

Box 35: The approach adopted in Japan and South Korea is reminiscent from the EU strategy

The prerogative to reduce dependence on imported mineral fertiliser is not confined to the EU borders. For instance, The Ministry of Agriculture, Forestry, and Fisheries in Japan released its 2030 targets for its "Green Food System Strategy" in 2022. It includes a 20 percent reduction in the use of mineral fertilisers with more ambitious targets foreseen by 2050. There is a large correspondence between its approach to realise these aims and the endeavours of the EU.

It aims to optimise the efficient use of fertilisers, and use domestic sources such as livestock manure or byproducts from food production, expand the use of biofertilisers, and increase its area in use by organic farmers (from a very small share of less than one percent to 25% by 2050).

In South Korea, the Eco-friendly Agriculture Promotion Act aims to put its agriculture on a more sustainable footing. While this is a broad strategy, ranging from reducing the use of pesticides to stimulating nature conservation and biodiversity. MAFRA (The Korean Ministry of Agriculture, Food and Rural Affairs) has formulated a plan to promote eco-friendly agriculture every five years in consultation with expert groups. It regularly monitors the status of usage of fertilisers, among other metrics.

Specifically with respect to fertilisers, it has placed maximum limits on fertilisers sprayed on crops, defines terms related to environment-friendly agriculture and fisheries, organic food, with certification procedures for organic food and materials. The government also encourages organic farming practices through subsidies and incentives, invests in research and development for alternative fertilisation techniques, emphasises soil health management strategies like crop rotation and conservation tillage.

Source: https://apbb.fftc.org.tw/article/373 and https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Japan%20Sets%20New%202030%20Targets%20for%20Green%20Food%20System%20Strategy%20_Tokyo_Japan_JA2022-0063.pdf and https://elaw.klri.re.kr/eng_mobile/viewer.do?hseq=39663&type=new&key=

8.1.3 Recommendations for future policy actions

According to interviewees, the EU Fertilising Products Regulation from 2019 was a big step forward. It allowed actors within the broader value chain to operate within a regulatory framework across the EU27. Previously, firms had to comply with various national regulations, leading them to pick selected markets and/or to incur additional costs that are hard to bear for smaller firms.

At the same time, it could be updated and made more conducive to stimulate innovation in the plant biostimulants industry. For example, only four genera of microorganisms can currently be used as components of microbial plant biostimulants, even though more micro-organisms can be deployed in practice. After scrutiny, a more comprehensive range could be allowed if deemed safe. As another example, hydrolysed proteins, chitin, and hygienised insect frass, three common components of PFC 6 Plant Biostimulants and the blends containing them, could be granted end-point status under the Animal By-Products Regulation for use in EU Fertilising Products.[536] In a similar spirit, and after an assessment of its impact, in particular with respect to food safety, changes to the regulatory framework tweak could enable the EU to meet its 2030 targets.

There are **still existing regulatory barriers when it comes to expanding organic-based fertilisers**. This includes clarifying the use of animal by-products and elaborating harmonised standards across the EU.[537] Updating this framework would take time, enacting it and transposing it into national legislation even more (also considering that the EU Fertilising Products Regulation came into force in 2022, three years after its approval). This slow procedure is ill-suited in a market with considerable innovation. One possible way to avoid being behind the innovation curve is to set up the criteria by which commercial activities can take place rather than establishing a positive list of microbes that are deemed safe for commercial use.

The potential to substitute mineral fertilisers with alternatives is substantial, also considering that the demand for compost and organic fertilisers is higher than the demand, according to interviewees. In 2017, about 48 million tonnes of bio waste underwent treatment, yielding an estimated 12 million tonnes of compost (constituting 74% of the total) and 4 million tonnes of anaerobic digestate (accounting for 26%). The production could triple in size if all countries follow the example of leading countries such as Austria, Belgium, and France in the separate collection of bio waste. As the EU imports around 25 million tons of mineral fertiliser a year, an

536 https://biostimulants.eu/publications/hydrolysed-proteins-chitin-andhygienised-insect-frass-should-be-granted-end-point-status-for-use-in-eu-fpr-eu-2019-1009/

537 https://agriculture.ec.europa.eu/document/download/82516359-29f8-4f0a-8a1c-63f0a2a563d1_en?filename=fertilisers-mo-2023-11-24-report_en.pdf

expansion of the market of organic fertilisers would have a sizeable impact.[538] These estimates do not include alternative organic fertiliser sources such as byproducts of food production, manure or sludge, which could also be more widely deployed. The government can facilitate this by investing in infrastructure for collecting, treating, and processing bio waste. By promoting the separate collection of bio waste and supporting composting facilities, the production of compost and digestate can be significantly boosted. Moreover, collaboration with the private sector and research institutions can foster innovation in composting techniques and enhance organic fertiliser quality and quantity. At the same time, it should be acknowledged that there are clear limits to the potential of organic sources of farming, and it is not entirely mutually interchangeable with mineral fertilisers.

Modern sustainable farm practices, including crop rotation and efficient fertiliser application, are vital for decreasing reliance on imported fertilisers. Crop rotation alternates crop types across seasons or years, preserving soil fertility, preventing erosion, and reducing pest and disease buildup. By strategically rotating crops, farmers optimise nutrient uptake, lessening the need for external fertilisers. Moreover, diligent fertiliser use entails precise application based on soil tests and crop needs. This targeted approach minimises waste and reduces overall fertiliser requirements. Farmers improve soil health, boost yields, and decrease reliance on external fertilisers by optimising nutrient management. Governments could put that into practice by providing training programmes, workshops, and educational materials to farmers, highlighting the benefits of crop rotation, efficient fertiliser application, and the use of organic fertilisers. Additionally, business development services tailored to farmers can be introduced to support the transition to sustainable practices. These services may include access to financing, technical assistance, and market information to help farmers implement and scale up sustainable farming methods effectively.

Research suggests that many farmers, including smaller ones, face challenges in adopting modern farm practices, particularly concerning reducing dependence on fertilisers. Some reasons for this include limited access to resources, such as capital, technology, and information, as well as smaller landholdings that may make implementing certain practices at scale difficult. Box 36 illustrates the approach adopted in the Netherlands that has successfully " decoupled” its agricultural output and use of mineral fertilisers and includes support mechanisms for small farmers.

Box 36: Twice as much food using half as many resources

The Netherlands has emerged as a leader in sustainable farming practices, particularly in the reduction of fertiliser use. Through innovative approaches and rigorous policies, the country has made significant strides towards more environmentally friendly and economically viable agricultural practices. The rallying cry “Twice as much food using half as many resources” set the ambition, whereby fertilisers, but also other inputs such as pesticides, had to be cut back, while increasing farm output at the same time.

One key aspect of the Netherlands' success in sustainable farming is its emphasis on precision agriculture techniques. Dutch farmers have adopted advanced technologies such as precision farming equipment, drones, and soil sensors to optimise the application of fertilisers. By precisely targeting nutrient inputs based on real-time data about soil conditions, crop health, and weather patterns, farmers can minimise wastage and improve the efficiency of fertiliser use.

Furthermore, the Netherlands has implemented stringent regulations and incentives to encourage sustainable farming practices. For example, the country has set strict limits on

[538] https://agridata.ec.europa.eu/extensions/DashboardFertiliser/FertiliserTrade.html

nutrient runoff and pollution from agricultural activities, incentivising farmers to adopt practices that reduce fertiliser use and mitigate environmental impacts. Additionally, government subsidies and support programmes are available to help farmers transition to more sustainable farming methods, including organic farming and integrated pest management. For instance, farmers can receive a voucher for a fixed amount of EUR 1 750 for training. Around 56 000 persons will benefit from advice, training or knowledge exchange or from participating in European Innovation Partnership operational groups supported by the CAP related to environmental or climate-related performance. About 2 100 advisors will be supported in their work to make innovation available to farmers, for example, crop production on wet soils.

Moreover, the Netherlands has invested heavily in research and innovation to develop new technologies and practices that support sustainable agriculture. Collaborations between government agencies, research institutions, and private companies have led to the development of innovative solutions for improving soil health, enhancing nutrient management, and reducing reliance on synthetic fertilisers.

Sources: https://agriculture.ec.europa.eu/system/files/2024-01/csp-at-a-glance-netherlands_en.pdf and https://eightify.app/summary/agriculture-and-farming/netherlands-leading-the-way-in-efficient-agriculture

The CAP (Common Agricultural Policy) is the main policy lever to encourage the efficient use of fertilisers, ideally guided by an Integrated Nutrient Management Plan, set at the EU. Even without the adoption of such a plan at the EU level, several member states have taken a holistic view to reduce the influence and encourage sustainable nutrient management practises, such as precision farming, setting aside lowland, catch crops, buffering strips along watercourses and conservation/zero tillage.

8.2 High-protein crops for animal feed

8.2.1 Overview of the value chain, positioning of SMEs and strategic vulnerabilities

Highlights:

- The EU heavily relies on imports for high-protein crops, especially soybeans, with limited self-sufficiency. This dependency poses strategic vulnerabilities for food security and agricultural competitiveness.
- Agronomic conditions, cost advantage of imports, scarcity of arable land, low profitability, and insufficient research all hinder the domestic production of high-protein crops in the EU.
- Small and medium-sized enterprises (SMEs), primarily comprising farmers, dominate high-protein crop production in the European Union. They face challenges competing with larger foreign competitors and rely on the support and a conducive ecosystem to thrive.
- The value chain for high-protein crops involves various stages, from seed production to consumption. Larger firms dominate segments like grain crushing and distribution, which are capital intensive and considerable volumes are at play. In contrast, SMEs play a significant role in cultivation and in more niche activities.
- The EU is working on a strategy to enhance protein self-sufficiency, focusing on increasing domestic production, developing alternative protein sources, and promoting efficiency and sustainability in crop production.
- Common Agricultural Policy (CAP) measures include income support for protein crops, coupled support schemes, and incentives for crop diversification to bolster domestic production. These are common throughout EU Member States and crucial to strengthen the market.
- Insect protein, algae, and bio-waste are emerging as potential alternatives to soybeans for animal feed. Regulatory relaxation and research investment are needed to scale up these alternatives. At the same time, there are concerns about their potential to decrease the dependence on foreign suppliers.
- Policies should ensure stability and predictability in support measures, facilitate biofuel production from high-protein crops, and invest in ecosystem development for sustainable crop production.
- Building a robust ecosystem around high-protein crops is essential to incentivise farmers to switch crops and invest in long-term production. Government support is crucial to address ecosystem development's "chicken and egg" problem.

8.2.1.1 The value chain in some depth

While it is widely acknowledged that the EU 27 is critically dependent on imports for plant-based proteins, it is useful to distinguish by protein content. As the table below illustrates, **there is a low self-sufficiency for products with a high protein content (i.e., between 30 and 50%), while there is ample supply for animal feeds with lower protein content.** At the same time, these products are not mutually interchangeable with subsectors within the live feed sector, such as poultry and pigs, which are reliant on high-protein meals. This dependency on imported crops is longstanding and sometimes labelled the "protein deficit." For instance, a comparison of the table below with 2012 data shows no marked difference in self-sufficiency ratios.[539] In a similar spirit, the notion that the protein deficit is problematic, both for reasons related to strategic autonomy and for environmental reasons, dates back a long time. In 2011, for instance, the European Parliament adopted a motion to deal with the unsustainability of this heavy dependency of the EU on soybean meal imports. The dependence was labelled longstanding at the time.[540]

Table 12. EU self-sufficiency for crops for animal feed

Product	Protein content (96)	Feed use 2020/2021 (million tonnes)	Feed use with EU origin (million tonnes)	EU self-sufficiency (96)
Soybean meal	45.5%	27.1	0.9	3%
Rapeseed meal	33%	12	8.3	69%
Common wheat	11%	38.2	36.2	95%
Barley	10%	35.6	35.6	100%
Maize	8%	63.5	50.4	79%
Fodder legumes	7.2%	84	84	100%
Silage maize	2.9%	244	244	100%
Grass	2.6%	629	629	100%

Source:https://www.europarl.europa.eu/RegData/etudes/BRIE/2023/751426/EPRS_BRI(2023)751426_EN.pdf

The shortage of protein-rich feed materials produced in the EU and imported from a limited number of countries is often perceived as a significant food security issue, impacting OSA. In a communication titled "Safeguarding food security and reinforcing the resilience of food systems" this was labelled a strategic concern.[541] Part of the focus on animal feed stems from its importance in the costs of livestock farmers, which can amount to up to 70% of overall costs.[542] In other words, **affordable and secure access to crops for animal feed is crucial for European farmers to be competitive in the global arena and to limit price inflation**.

As there is no genuine issue with OSA regarding low-protein crops, this report focuses on high-protein crops, especially soy, whose dependence is close to 100%. Brazil, the United States, and Argentina represent the main exporters of high-protein crops, particularly soybeans, to the EU27. Various reasons have been put forward to explain this large dependence, such as[543]:

- The agronomic conditions, relatively unfavourable towards the production at the scale of high protein crops;

539 https://ec.europa.eu/eip/agriculture/sites/default/files/fg2_protein_crops_final_report_2014_en.pdf

540 https://www.europarl.europa.eu/doceo/document/A-7-2011-0026_EN.html

541 https://eur-lex.europa.eu/resource.html?uri=cellar:5391557a-aaa2-11ec-83e1-01aa75ed71a1.0002.02/DOC_1&format=PDF

542 https://www.researchgate.net/publication/355394668_Future_of_Animal_Feed_An_Industry_in_Transition#:~:text=Feed%20expenses%20are%20the%20largest%20component%20of%20the,costs%2C%20especially%20in%20species%20like%20swine%20and%20poultry.

543 https://agriculture.ec.europa.eu/farming/crop-productions-and-plant-based-products/cereals/development-plant-proteins_en

- The relative cost advantage of imports (partly at the detriment of the environment);
- The scarcity of arable land in the EU27 and competition over other uses;
- The low profitability of such crops;
- A lack of research on breeding, agronomic practices and different uses of high-protein crops.

The third point is often overlooked. While there is ample concern about the competitiveness of EU farmers versus rivals from other parts of the world, with greater economies of scale and less environmental concerns, farmers in Europe often turn to high-volume crops such as wheat for which there is an established eco-system rather than high-protein crops which is perceived as a risky choice. Box 37 further illustrates.

Box 37: The role of the broader eco-system in developing crops

Farmers in the EU often grow “traditional” crops such as wheat, corn, and barley because they are part of a well-established, functioning, and supported ecosystem. Wheat and corn are widely grown in the EU because of their versatile uses and established markets, which is less the case for “niche crops”. Both crops have a strong demand for human consumption, animal feed, and industrial applications, making them attractive options for farmers seeking stable and profitable markets. Wheat is a staple food crop used in bread, pasta, and other processed foods, while corn is used for animal feed, ethanol production, and as a raw material in various industries.

In regions where wheat and corn are the predominant crops, grain collectors, crushers, processing firms, and so on that are further downstream in the market typically have well-established supply chains and infrastructure optimised for handling these crops. They invest in storage facilities, transportation networks, and processing plants specifically designed for wheat and corn, allowing for efficient and cost-effective handling of large volumes.

Seed companies are crucial in supplying farmers with the seeds needed to grow various crops. In the case of high-volume crops, seed companies are highly active and invest heavily in research and development to develop high-yielding, disease-resistant varieties tailored to different growing conditions. This reflects the strong demand from farmers and the established markets for these crops. As a result, seed companies may prioritise their resources and investments while devoting fewer resources to the breeding and development of pea and lupine varieties, for instance.

In a similar spirit, pest control measures, including the use of pesticides and integrated pest management (IPM) strategies, are well-established for these crops. Seed treatments, foliar sprays, and soil treatments are commonly used to protect wheat and corn crops from pests such as aphids, thrips, and corn borers. Additionally, ongoing research and development efforts focus on developing new pest-resistant varieties and alternative pest control methods to minimise the reliance on chemical pesticides. For more minor crops, these alternatives are much less present. Fertiliser application practices, including the timing, rate, and placement of fertilizers, are highly developed for high-volume crops to optimise nutrient uptake and crop yields. Precision agriculture technologies, such as soil testing, variable rate application, and fertigation, are widely adopted to ensure efficient nutrient management and minimise environmental impact. Again, these practices are much more developed for high-volume crops. Other ecosystem segments, such as biostimulants or precision farming techniques, are similarly developed with high-volume crops in mind.

The value chain comprises eight stages, from the production of seeds by specialised companies to the consumption within the EU (see Figure 39).

Figure 39. The value chain for high-protein crops for animal feeds

Source: Authors

Finally, it should be noted that there is some overlap between the cultivation of high-protein crops for animal feed and for the food market (i.e. for human consumption), as well as bio-fuels. The cultivation of high-protein crops for human consumption can be a profitable growth market, but it was relatively niche at 7% in volume in 2017.[544] The use of rapeseed as a biofuel is considered crucial to the expansion of the market. Through the processing of rapeseed, oil is produced as a side-product, which can then be used as a biofuel. Without this market, the cultivation and processing of rapeseeds (sunflower seeds and similar crops) becomes much less profitable and often economically unviable.

8.2.1.2 The role of EU SMEs

The farmers of high-protein crops are typically SMEs. Rapeseed and sunflower farmers (which are the most common crops within the high-protein category) would mostly fit within this SME framework, according to interviewees, especially considering the following aspects:

- **Size of operations**: many rapeseed and sunflower farmers operate on a scale that categorises their farms as small or medium-sized businesses, particularly if one considers the family-owned and operated farms prevalent in agricultural sectors across the EU. This is even more the case for legume producers such as peas, faba beans, and lupins, which are niche crops compared to wheat, corn, and barley.
- **Revenue**: the revenue generated from cultivation, while potentially significant, often falls within the SME range, especially for individual farmers or farming cooperatives that do not engage in large-scale industrial agriculture.
- **Independence**: most rapeseed and sunflower farmers operate independently, managing their cropping decisions, sales, and business operations, which aligns with the SME model.

In addition to the production, SMEs are sometimes active in the steps between crop production and market deployment. In terms of volumes, the market is dominated by large firms that are active in segments such as grain crushers, grain collectors, and distribution and sale.

Most members of FEDIOL, the EU vegetable oil and protein meal industry association, which represents European oilseed crushers, vegetable oil refiners and bottlers, are small or

544 https://agriculture.ec.europa.eu/document/download/e413dfd9-f7cd-449f-8c1a-8e08f2f7d6d4_en?filename=report-plant-protein-conference-2018_en.pdf

medium-sized. These firms are active in relatively specialised or niche markets, for example, with crushing, refining, and processing of only one crop, whereas large companies active in the sector have a more diversified portfolio of activities.

8.2.2 OSA goals and overview of relevant policy initiatives

An EU Strategy on proteins is underway and expected in the first half of 2024. The European Parliament's Committee on Agriculture and Rural Development (AGRI) has prepared a draft report[545] which outlines potential avenues that would reduce this dependency by:

- **Increasing domestic production**. In practice, this means coupling income support (CIS) for legume and protein crops as part of the CAP (Common Agricultural Policy) strategic plan for the 2023-27 period and how the Member States implement that. At least 19 Member States intend to use the possibilities to provide 'coupled support' for protein crops in their CAP Strategic Plans for 2023-2027.[546]
- **Developing and deploying alternative proteins, such as microbial protein, insect consumption (by livestock), seaweed and microalgae**. In that sense, it is important to note that regulations have been relaxed recently. As one example, the Commission authorised insect-processed proteins in fishmeal in 2017 and in poultry and pig feed in 2021. This is also in line with repeated European Parliament calls to diversify animal feed sources.[547] At the moment, such non-conventional protein sources are still, by and large, limited to mono-gastric feeds and pet food, but there is potential beyond the current applications.[548]
- **Greater efficiency and sustainability**. Enhanced feed autonomy can be achieved by strategically utilising available resources facilitated by advancements in digital technologies. Recent breakthroughs in animal nutrition science and formulation software empower farmers and feed manufacturers with a deeper comprehension of the nutritional needs of livestock. This knowledge enables a more efficient utilisation of feed ingredients and the production of optimised compound feed. By leveraging these technologies, farmers can reduce input costs while maintaining the health and productivity of their livestock.

These recommendations are aligned with the Versailles declaration of the European Council, which, among other recommendations, called for boosting EU plant protein production. The - European Parliament resolution of 24 March 2022 on the need for an urgent EU action plan to ensure food security inside and outside the EU in light of the Russian invasion of Ukraine again highlighted the need for greater self-dependence in animal feed products.[549]

A 2011 motion by the European Parliament lists the economic and societal advantages associated with expanding European-grown protein crops. This includes economic benefits for farmers and the feed industry, nitrogen assimilation and fixation in soil leading to decreased synthetic nitrogen fertiliser use and greenhouse gas emissions, reduced CO2 emissions and ozone production, improved nutrient storage balance, decreased soil acidification, enhanced disease resistance, minimized weed proliferation, improved soil structure, reduced herbicide and plant protection treatment usage, lower energy consumption, increased biodiversity, and support for pollination when protein crops are integrated into crop rotation. Additionally, it highlighted improved water management, resulting in decreased nutrient runoff into

[545] https://www.europarl.europa.eu/RegData/etudes/BRIE/2023/751426/EPRS_BRI(2023)751426_EN.pdf

[546] https://eur-lex.europa.eu/resource.html?uri=cellar:5391557a-aaa2-11ec-83e1-01aa75ed71a1.0002.02/DOC_1&format=PDF

[547] https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2023)739328

[548] Non-conventional alternative proteins in feed regulations in the EU. Is it the answer to less soymeal in animal feed? - Pen & Tec Consulting (pentec-consulting.eu)

[549] https://www.europarl.europa.eu/doceo/document/TA-9-2022-0099_EN.html

groundwater in mixed cropping systems, and the ability of protein crops to adapt to European climatic conditions, thereby stabilising and enriching agricultural biodiversity within the production system.[550]

The CAP has given increasing attention to the development of (high-)protein crops such as soybeans, peas, beans, lupins, chickpeas, lentils, faba beans, alfalfa, cloverand oilseed rape. A 2013 study recommended nine policy options to support protein crops, including promoting on-farm crop diversification measures, designating areas cultivated with legumes as ecological focus areas, implementing regional and coupled support schemes for protein crops, enhancing support for organic farming, promoting legumes through agri-environment schemes, strengthening climate protection policies following reduced greenhouse gas emissions and increased carbon sequestration in soil, policies on nutrient (nitrogen fertilisers) use in agriculture, supporting producer initiatives for networking and knowledge dissemination, and investing in research, breeding, and technical progress.[551]

As a result of the increasing emphasis on home-grown protein crops, the EU Agricultural Outlook, published in January 2024, expects the production of high-protein crops for animal feed, in particular pulses and soya beans, to expand within the union and import volumes to decline between now and 2035. At the same time, the expansion of domestic production comes from a relatively low base and the dependence on foreign crops will remain high according to the benchmark estimate.[552] Box 38 provides more information about why Brazil is the world leader and what lessons the EU could draw.

Box 38: Why Brazil has emerged as a global leader in high-protein crops for animal feeds

According to data from the National Supply Company (Conab), Brazil is expected to maintain its status as the top soybean producer in the next ten years, ahead of its main competitors, the United States and Argentina. In the 2020/21 season, Brazil achieved a record soybean production of 4 994 million bushels, marking an 8.9% increase from the previous season's record of 4 587 million bushels. This season also saw a record-breaking harvested area of 95.16 million acres, up by 4.2% compared to the previous season.

Many of the competitive advantages Brazil, and other leading producers, enjoy are hard to replicate in the EU. This includes the favourable agro-climatic conditions, and especially the extensive arable land that is available at cheap prices. The land area that could be cultivated in the EU is much more constrained, and the acres that could be devoted to high-protein crops are typically much more expensive to buy. Environmental standards, or the relatively lack thereof, could also be considered as a competitive advantage enjoyed by Brazilian producers.

At the same time, there are some lessons that could be applied to the EU. An independent report notes that this is "driven by heavy public and private investments, technological development and professional education, technical guidance, all kinds of infrastructure viability and the growing demand by the international market[553]." The Brazilian Government has implemented agricultural subsidies and incentives to encourage farmers to grow high-protein crops, reducing production costs and financial risks associated with cultivation. In 2022, the soybean production chain in Brazil received tax incentives and exemptions totaling R$56.8 billion, equivalent to approximately EUR 9.2 billion at the current exchange rate.

[550] European Parliament. Report: The EU protein deficit: what solution for a long-standing problem? (2010/2111(INI)). Available: https://www.europarl.europa.eu/doceo/document/A-7-2011-0026_EN.html.

[551] https://library.wur.nl/WebQuery/wurpubs/fulltext/262633

[552] https://agriculture.ec.europa.eu/document/download/a353812c-733e-4ee9-aed6-43f8f44ca7f4_en?filename=agricultural-outlook-2023-report_en_0.pdf&prefLang=fr

[553] https://wwfbrnew.awsassets.panda.org/downloads/the-cost-of-soybeans-to-brazil_-trad_ing_v-06--1-.pdf

Additionally, Brazil has also prioritised research and development (R&D) initiatives in agriculture, leading to advancements in crop breeding and agronomic practices, further enhancing productivity. Trade policies promoting export-oriented agriculture have expanded Brazil's access to international markets, driving demand for high-protein crops and supporting agricultural growth.

The industry is concentrated in the Matopiba Region, thanks in part to the presence of agribusiness hub and logistics facilities. This region has benefited from investments in infrastructure development, including transportation networks and processing facilities, which have facilitated the efficient production and distribution of crops.

Sources: https://wwfbrnew.awsassets.panda.org/downloads/the-cost-of-soybeans-to-brazil_-trad_ing_v-06--1-.pdf, https://farmdocdaily.illinois.edu/2021/07/brazil-likely-to-remain-world-leader-in-soybean-production.html,

8.2.3 Recommendations for future policy actions

First, one important recommendation is to **allow producers of rapeseeds and other high-protein crops to act as producers of biofuel**. As highlighted before, the production of biofuel and animal feed is often complementary, and without a market for biofuels, the viability of the cultivation and processing of these crops is endangered.

Second, a regulatory framework is in place to allow alternative sources of animal feed. Key regulations on feed materials are Regulation (EC) No 767/20091 ("the Feed regulation") and Regulation (EU) No 68/20132 (the Community Catalogue of feed materials, "the Catalogue"). The ban on feeding animal remains to domestic livestock has also been relaxed. **There is recognition among industry actors that regulations need to be subject to regular review and update, if need be, in line with new scientific evidence**. For example, the EU has launched a consultation process to modernise the rules on feed additives.[554]

Third, the **coupled income support for farmers in the CAP** is described by interviewees as an indispensable part of the equation. This can include direct payments, price support measures, or targeted investment subsidies under specific requirements. The design and implementation of coupled support measures are subject to EU regulations and guidelines, which define the eligibility criteria, payment rates, and conditions for receiving support. A significant part of rapeseed production in the EU has expanded significantly and is related to such support measures. There is concern that, without such support schemes, the current output of high-protein crops in the EU would fall, further raising the dependence on imports. It is important to note that Member States have an essential role in implementing and administering these direct payment schemes, including determining eligibility criteria and distributing payments to farmers, as well as designing and implementing rural development plans.

Fourth, **any support measures have to be long-term, stable and predictable**. Switching crops takes significant time and involves sunk costs that are only borne if producers are sufficiently convinced that this will be rewarded over the long term.

Fifth, the broader ecosystem for high-protein crops is relatively nascent and underdeveloped in the EU. This does not instil confidence in the market and discourages farmers from switching to these crops and making long-term investments. As long as volumes do not reach critical mass, other eco-system actors will not produce new seeds, invest in specialised processing plants, explore alternative uses, develop tailored pest control measures, etc. Without these

[554] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12624-Animal-nutrition-modernisation-of-EU-rules-on-feed-additives_en

investments, volumes will not significantly expand. **Governments need to support "ecosystem investments" to eliminate this "chicken and egg" problem**. Various measures aimed at fostering confidence and incentivising participation from the industry. Public-private partnerships (PPPs) and co-investment schemes can play a crucial role. Governments can provide financial incentives such as tax breaks, subsidies, or grants to attract private investment. Establishing clear regulatory frameworks and guidelines can also provide certainty to investors, reducing perceived risks associated with eco-system investments. Additionally, creating platforms for collaboration between government agencies, industry stakeholders, and financial institutions can facilitate knowledge sharing and resource pooling.

The EU, or individual Member States could also try to foster efficiency gains by encouraging live feed formula to include a lower proportion of imported soy while maintaining the nutrient qualities. One potential model is China. As the largest importer of high-protein feeds, largely dependent on imports from its geopolitical rival, the United States, the Ministry of Agriculture has issued guidelines and later binding targets for the industry. Consequently, the proportion of soybean meal in the feed will be cut from 14.5% in 2022 to under 13% by 2025, which is likely to drop below 12% by 2030.[555]

A final recommendation is to **fund research and scale-up initiatives into alternative sources of protein-rich sources of animal feed**. As Box 39 shows, these alternatives show some promise but are typically in the experimental or pilot phase and have remained so for a long period. In other words, doubts abound about whether these sources represent a viable alternative to food imports at any scale and whether they can make a material impact. It is important to acknowledge that a sizeable switch may not be realistic in the near term due to various constraints. These include the need for further research and technological advancements, investment in infrastructure and production systems, regulatory approval for novel feed ingredients, and market acceptance from producers and consumers. The EU devoted substantial funding under the Horizon 2020 programme to research projects identifying alternative protein sources (such as insects, algae or microbes) and has placed innovation in the sustainability of food systems among the critical priorities for current Horizon Europe funding.

A 2023 report commissioned by the Food Standards Agency in the United Kingdom states that "*the economics of alternative protein sources at large scales is a major concern for their adoption, since only a few alternative protein production and supply systems have been tested and exploited commercially to date*."[556] Member States and the European Commission can explore the potential of alternative sources further as a long-term endeavour.

Box 39: Alternative sources of proteins for animal feed

- **Algae**: Algae are considered a promising source of protein for animal feed due to their rapid growth rate, high protein content, and minimal land and water requirements. Algae-based feeds have been studied for use in aquaculture, poultry, and livestock diets. Research has shown that certain species of algae can be cultivated on non-arable land using wastewater or carbon dioxide from industrial sources, making them potentially sustainable alternatives to soybeans. However, challenges remain in terms of scaling up production, reducing production costs, and overcoming regulatory hurdles related to novel feed ingredients.
- **Insects**: Insects are another alternative protein source that has gained attention for animal feed applications. Insects such as black soldier fly larvae, mealworms, and crickets are rich in protein, essential amino acids, and micronutrients, making them

[555] https://nutrinews.com/en/food-security-concerns-prompt-china-to-cut-soybean-meal-from-animal-feed/

[556] https://www.food.gov.uk/research/emerging-challenges-and-opportunities/the-future-of-animal-feed?print=1

suitable for inclusion in feed formulations. Insect-based feeds have been explored as sustainable alternatives to conventional protein sources like soybeans, particularly in aquaculture and poultry production. While the insect farming industry is still in its early stages of development, there is growing interest and investment in scaling up insect production for animal feed purposes.

- **Bio-waste**: Bio-waste, including by-products from food processing, agricultural residues, and food waste, can be utilized as feed ingredients through processes such as fermentation, enzymatic hydrolysis, and microbial conversion. Bio-waste-derived feeds have the potential to reduce waste generation, lower feed costs, and provide alternative protein sources for livestock and aquaculture production. Research and pilot projects have demonstrated the feasibility of using bio-waste-derived feeds in animal diets, but further optimisation and commercialisation are needed to make them economically viable and scalable.

Source: Naylor, R. L., Goldburg, R. J., Primavera, J. H., Kautsky, N., Beveridge, M. C., Clay, J.,& Troell, M. (2000). Effect of aquaculture on world fish supplies. Nature, 405(6790), 1017-1024. Makkar, H. P. S., Tran, G., Heuzé, V., & Ankers, P. (2014). State-of-the-art on use of insects as animal feed. Animal Feed Science and Technology, 197, 1-33. Becker, E. W. (2007). Micro-algae as a source of protein. Biotechnology Advances, 25(2), 207-210. van Huis, A. (2013). Potential of insects as food and feed in assuring food security. Annual Review of Entomology, 58, 563-583.

9 OSA and SMEs in the energy-intensive industries ecosystem

This chapter will focus on promising technologies to limit the emission of carbon dioxide by energy-intensive industry. Energy-intensive industries need to reach climate neutrality by 2050. Reaching that target will not only contribute significantly to the green ambitions of the EU but also give a powerful stimulus to the competitiveness of these industries. We focus on three technologies that can apply to different subsectors within the broader sector of energy-intensive industries. Heat pumps, carbon capture technology, and electrolysers all contribute to improving energy efficiency and flexibility in the energy system and are key technologies for energy-intensive companies. Heat pumps offer efficient heating and cooling solutions that can reduce energy consumption and peak demand. Carbon capture technologies enable the capture and utilisation of CO2 emissions, reducing the environmental impact of fossil fuel use. Electrolysers provide a means to store and utilize surplus renewable energy, enabling demand response and grid balancing.

There is some overlap between these technologies. By integrating heat pumps, carbon capture, and electrolysers, emitters of CO2 can reduce their emissions and even get value from captured CO2 emissions, contributing to the circular economy and sustainable development. In particular, carbon captured from industrial processes or power plants can be utilised by electrolysers to produce valuable products such as hydrogen, syngas, or synthetic fuels. These products can serve as clean energy carriers or feedstocks for various applications, including transportation, industry, and power generation.

Some recommendations, therefore, transcend the level of these individual technologies. In particular, governments ought to play a pivotal role in setting guidelines for the sustainable utilisation of biomass and ensuring an ample supply of renewable electricity to meet the mounting demands of industry. Moreover, numerous technologies necessitate significant investments in infrastructure for electricity, hydrogen, and CO2 networks. Such infrastructure often surpasses the capacity of individual companies, thus necessitating government assistance in the establishment and operation of such networks.[557]

9.1 Heat pumps

Highlights:

- Heat pumps offer significant potential for energy savings and CO2 abatement across various sectors, including large-scale installations for energy-intensive industries and small-scale installations for households and small emitters.
- The European Commission recognises heat pumps as pivotal technology for achieving climate-neutrality objectives, particularly through initiatives like the Green Deal Industrial Plan and the Net-Zero Industry Act.
- Large-scale heat pump installations are often tailor-made, while smaller installations are more standardised. European firms, particularly SMEs, have a strong position in larger-scale installations but face fierce competition, especially from Asian countries, in smaller installations where price considerations generally weigh more.

[557] https://www.europarl.europa.eu/RegData/etudes/STUD/2020/652717/IPOL_STU(2020)652717_EN.pdf

- The heat pump value chain involves various phases, with labour-intensive activities like installation, service provision, and maintenance taking place close to end customers.
- Barriers to industry development include high electricity prices, skills shortages, perceptions of heat pump technology as unproven, and dependence on foreign suppliers for components like semiconductors.
- EU SMEs play a significant role in the heat pump industry, with approximately two-thirds of hydronic heat pumps sold annually in the EU produced within the region. The industry employs around 320,000 people across the EU, with a majority of production sites being SMEs.
- European countries, particularly Central European nations, are experiencing substantial growth in new heat pump production capacity.
- Financial support schemes and regulatory measures are common across the EU to stimulate the heat pump market, with initiatives like the Renewable Energy Directive and the Energy Efficiency Directive playing crucial roles.
- Recommendations for future policy actions include ensuring policy predictability and consistency, fostering collaboration between industry stakeholders and government bodies, streamlining regulatory processes, and developing quality standards for components to ensure secure and sustainable production within the EU.
- The European Commission's Heat Pump Action Plan, aimed at accelerating the rollout of heat pumps across the EU, has been delayed, leading to a decline in sales. Suggestions for improvement include establishing an EU Heat Pumps Observatory, streamlining the permitting process, and implementing quality standards for components.

9.1.1 Overview of the value chain, positioning of SMEs and strategic vulnerabilities

Heat pumps have significant energy savings and CO2 abatement potential across various sectors. In large-scale installations for energy-intensive industries, heat pumps can efficiently recover waste heat from industrial processes or ambient sources like air, water, or the ground. As one example, heat pumps can reduce energy use in the paper industry by half, according to recent estimates.[558] Heat pumps can substantially reduce energy consumption and greenhouse gas emissions associated with fossil fuel combustion by utilising this recovered heat for space heating, hot water production, or industrial processes. Additionally, heat pumps can enable the electrification of industrial processes, thereby reducing reliance on fossil fuels and contributing to decarbonisation efforts. Heat pumps play a pivotal role in the REPowerEU plan, launched in 2022 to make the EU independent of Russian fossil fuels well before 2030. Other independent sources confirm that heat pumps are absolutely vital in reducing the dependence on imported gas.[559]

The European Commission's report on the competitiveness of clean energy technologies underscores the imperative to expedite the uptake of diverse heat pump variants across all

[558] https://www.ehpa.org/news-and-resources/news/saving-50-energy-in-paper-industry-through-heat-pumps/
[559] https://www.iea.org/reports/the-future-of-heat-pumps/executive-summary

applications. Recognizing heat pumps as pivotal technology, the Green Deal Industrial Plan aligns with the EU's climate-neutrality objectives as articulated in the Net-Zero Industry Act.

In small-scale installations for households and small emitters, heat pumps offer an energy-efficient alternative to traditional heating and cooling systems. By extracting heat from the air, water, or ground and transferring it indoors for heating or outdoors for cooling, heat pumps can provide space conditioning with lower energy consumption compared to conventional heating and cooling technologies. This results in reduced energy bills for homeowners and lower carbon emissions from residential buildings. Moreover, heat pumps can facilitate the integration of renewable energy sources like solar and wind power by providing demand-side flexibility and enabling efficient use of surplus electricity through thermal energy storage.

It is important to distinguish between large and small heat pump installations. Heat pumps can be considered large if they exceed capacities of 100 kW. The largest machines exceed the megawatt range threshold, with the largest units providing 35 MW for a single machine.[560]

In general, the large-scale installations are tailor-made to some extent, while the smaller installations are more standardised. Interviews reveal that European firms, many of them SMEs, have a very strong position in the larger-scale installations and a much less strong position in the small installations. For the latter, price factors weigh large on the investment decision, and competition on price, especially from Asian countries, is relatively fierce. The European Commission estimates that between 60 and 73% of the current demand for heat pumps is met by production within the union and the rest by imports. It notes that EU firms are technological leaders in all areas, but especially in larger heat pumps. It also notes that competition, especially from China, is most pronounced in heat pumps with a lower power range.[561]

EU-wide data by size class (of the installation) is hard to come by. The sector association in Italy, which hosts a sizeable number of production facilities, mostly in the north (Figure 41), confirms the relationship between the size of the installation and the presence of EU firms; the larger the power range, the stronger the position on Italian manufacturers (**Errore. L'origine riferimento non è stata trovata.**).

Table 13. A2W heat pumps installations in Italy by power size.

Share of A2W heat pumps production in Italy*	Power range
22%	< 17 kW
65%	>17 kW and < 50 kW
81%	>50 kW and < 100 kW
87%	> 100 kW

Notes (*). Values may slighly differ since we gather data for export without further analysing if the destination country is within EU27 or not. Source: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13771-Heat-pumps-action-plan-to-accelerate-roll-out-across-the-EU/F3423339_en

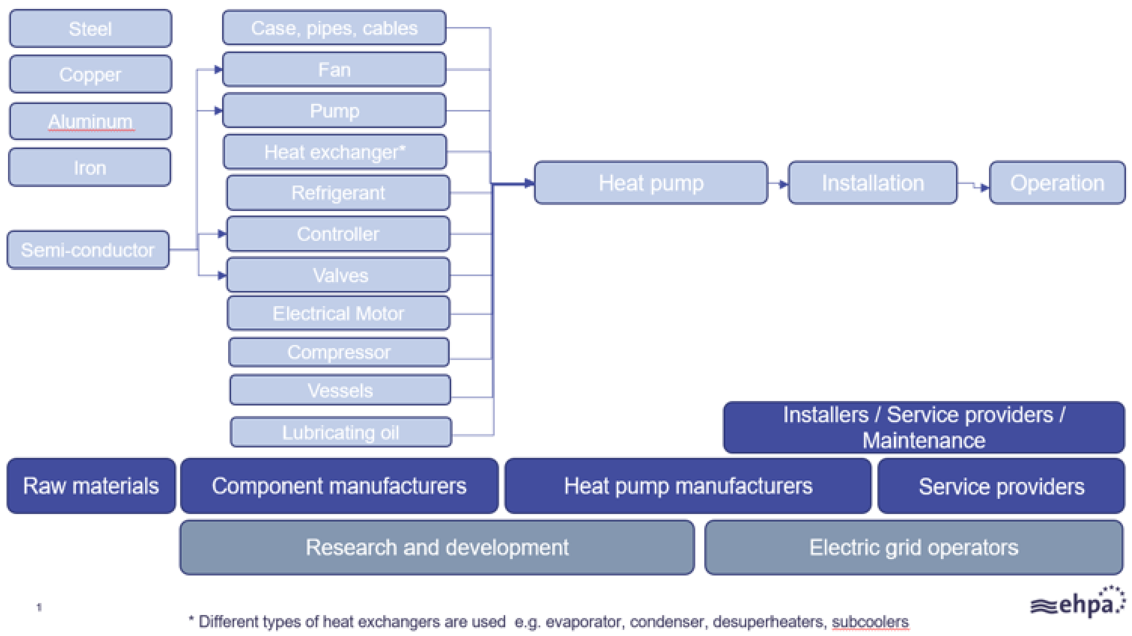
The value chain is composed of different phases (Figure 40). The last phases of the chain, i.e. installation, service provision, and maintenance are relatively labour-intensive and take place close to the end costumer. By nature, these activities are not easily outsourced. This is a prime reason why the industry is poised to employ up to half a million people in the EU27 by 2030 (see below). It should be noted that the availability of this skilled labour force and other

[560] https://www.ehpa.org/wp-content/uploads/2022/11/Large-heat-pumps-in-Europe-and-industrial-uses_2020.pdf

[561] https://single-market-economy.ec.europa.eu/system/files/2023-03/SWD_2023_68_F1_STAFF_WORKING_PAPER_EN_V4_P1_2629849.PDF

barriers in this part of the chain can possibly hamper developments in phases one and two, and are therefore discussed in the remainder of this section. At the same time, the focus of this study lies very much on the manufacturing and assembly of components, as these are areas where OSA is more relevant. In addition, R&D activities are significant within the industry and are represented as a "transversal activity" in Figure 40, representing another domain where issues of strategic autonomy come into play.

Figure 40. The heat pumps value chain



Source: EHPA

9.1.1.1 Barriers towards the development of the industry

Research indicates a clear difference between the "technical" potential of the heat pump industry and its "economic" potential.[562] **In other words, many potential projects have environmental merit (in terms of energy savings and CO2 abatement), but are considered as not economically viable**. Several reasons stand out why this gap is considered wide (based on interviews and the relevant literature):

- **The high electricity price is problematic for the industry**. More precisely, the electricity-to-gas price ratio represents a risk factor, as a ratio of more than three means that many installations are not economically viable. In addition, the expectations regarding the return on investment are high, with returns sometimes expected within two years after the instalment.[563]
- In addition, **skills shortages are pronounced**. This manifests itself especially concerning the installation of (advanced) heat pumps, which requires specialised expertise that many heating installers do not possess. This puts a considerable break on the industry. Energy experts who can provide appropriate guidance are also in short

[562] https://www.ehpa.org/wp-content/uploads/2022/11/Large-heat-pumps-in-Europe-and-industrial-uses_2020.pdf
[563] https://www.ehpa.org/wp-content/uploads/2022/11/Large-heat-pumps-in-Europe-and-industrial-uses_2020.pdf

supply. In total, the sector employed 320 000 workers in 2023, and would need to reach 500 000 skilled workers by 2030 to meet the EU targets.[564]

- **Heat pumps are sometimes considered unproven technologies**, whereas in practice, that is no longer the case, and the technology is relatively mature. This perception leads to hesitation among potential beneficiaries.
- **Several components of heat pumps require semi-conductors, implying that the dependence on foreign suppliers of semi-conductors (and the associated raw materials) also risks the strategic autonomy of the heat pump sector**. One report indicates that EU manufacturers may face substantial supply delays for semiconductors, as well as some other crucial components like pumps, inverters, evaporators, compressors and heat exchangers. Such delays undermine the short-term competitiveness of the EU, as many Asian manufacturers enjoy smoother access to materials and components.[565]
- The **high upfront costs** are widely considered a constraining factor and a major reason many governments have devised subsidy schemes.[566] It should be noted that these high installation and retrofitting costs are also a barrier to industrial use of high-scale heat pumps.[567]
- There are **concerns about China's rising importance**. China's export trade value in heat pumps to the EU27 rose by 400% between 2017 and 2021, marking it as the most important foreign actor by far.[568] This could potentially compromise product quality as well as undermine the economic benefits of onshore manufacturing in the EU. The concerns mainly pertain to the long-term competitiveness, mainly in prices, of European manufacturers. Otherwise stated, the strategic autonomy could be endangered if the projected expansion of demand would be primarily met by Chinese producers rather than domestic ones.

At the EU level, the sector is being strengthened by the revised Energy Performance of Buildings Directive (EPBD), the Renewable Energy Directive (RED), the Energy Efficiency Directive, the EU Strategy for Energy System Integration, revised ecodesign requirements and energy labelling, the proposed extension of the Emissions Trading Scheme to the buildings sector, the proposed revision of the Energy Taxation Directive, Next Generation EU and its Renovation Wave, and most recently REPowerEU In 2022. The European Commission introduced the REPowerEU initiative, aiming to achieve EU independence from Russian fossil fuels by 2030. Heat pumps, identified as a natural alternative to gas and oil boilers, are pivotal in realising this goal. The plan targets the installation of 30 million heat pumps, primarily hydronic systems, by 2030, heralding a substantial overhaul of Europe's heating and cooling sector.[338]

9.1.1.2 The role of EU SMEs

First of all, it should be noted that **robust market intelligence on the heat pump industry within the EU is currently lacking**. The numbers provided in this section are, therefore, based on estimates. For example, it is estimated that, at present, approximately two-thirds of hydronic

---

[564] Toleikyte, A., Roca Reina, J. C., Volt, J., Carlsson, J., Lyons, L., Gasparella, A., Koolen, D., De Felice, M., Tarvydas, D., Czako, V., Koukoufikis, G., Kuokkanen, A., Letout, S, The Heat Pump Wave: Opportunities and Challenges, Publications Office of the European Union, Luxembourg, 2023, doi:10.2760/27877, JRC134045

[565] https://www.europeanfiles.eu/environment/heat-pumps-made-in-eu-lessons-learned-for-a-successful-industrial-policy

[566] https://www.iea.org/reports/the-future-of-heat-pumps/executive-summary

[567] https://www.gminsights.com/industry-analysis/europe-industrial-heat-pump-market#:~:text=The%20market%20size%20of%20industrial,renewable%20energy%20solutions%20across%20industries.

[568] The EU Hydronic Heat Pump Manufacturing Market Assessment, provided by the European Heath Pump Association (EHPA).

heat pumps sold annually in the EU, totalling 1.2 million units, are produced within the EU. The remaining one-third is estimated to be sourced from other parts of the world, primarily from China.[569] A particular challenge for this project is that the exact contribution and role of companies by size class is unavailable.

While exact numbers are not available, it is clear that the heat pump industry in Europe is both established and innovative, with significant participation from SMEs alongside a few larger manufacturers, none of which dominate the market entirely. Europe hosts approximately 170 heat pump factories, primarily focused on assembly rather than component manufacturing. An interview with the sector association reveals that the majority of them are SMEs. While many heat pumps are produced within the EU, compressors are mostly imported from China. Consequently, a substantial portion of the value generated within the heat pump value chain remains within the EU. Increased demand has led to notable growth in EU manufacturing, with a record year-to-year increase of 30% in 2021, amounting to EUR 3 billion in production value. Sweden has emerged as the leading producer (in terms of volume), with France and Germany completing the top three.[570]

In total, the industry employed around 320,000 people across the EU in 2020.[571] The manufacturing sites are dispersed across all of Europe, as Figure 41 illustrates. Interviews confirm that the majority of these production sites are SMEs, even though exact numbers are not available. In addition, these production sites are often located in rural or remote areas (although typically not too far from end-users), providing job opportunities outside of major metropolitan areas.

There are several reasons behind this finding. Due to their bulkiness and inefficiency in long-distance transportation, heat pumps favour local manufacturing. They also frequently cater to specific end-markets, which can vary substantially, including historical practices, adaptation to regional conditions such as climate and space constraints, noise regulations, and compliance with local regulations concerning recyclability, efficiency, safety, and refrigerants. Finally, production costs, for example, related to land prices, tend to be lower outside of major urban areas.[572]

---

[569] The EU Hydronic Heat Pump Manufacturing Market Assessment, provided by the European Heath Pump Association (EHPA).

[570] Toleikyte, A., Roca Reina, J. C., Volt, J., Carlsson, J., Lyons, L., Gasparella, A., Koolen, D., De Felice, M., Tarvydas, D., Czako, V., Koukoufikis, G., Kuokkanen, A., Letout, S, The Heat Pump Wave: Opportunities and Challenges, Publications Office of the European Union, Luxembourg, 2023, doi:10.2760/27877, JRC134045

[571] https://single-market-economy.ec.europa.eu/system/files/2023-03/SWD_2023_68_F1_STAFF_WORKING_PAPER_EN_V4_P1_2629849.PDF

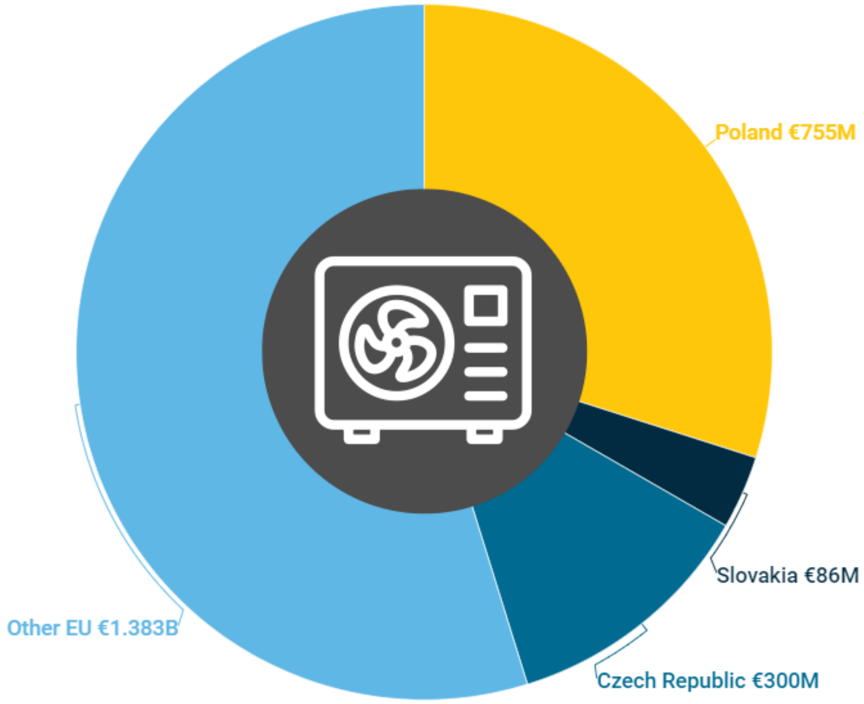
[572] The EU Hydronic Heat Pump Manufacturing Market Assessment, provided by the European Heath Pump Association (EHPA).

Figure 41. Heat pump manufacturing sites in the EU, 2023

Source: EHPA

In terms of new capacity, Central European countries are doing disproportionately well, with a "heat pump valley" taking root in the border area between Poland, Slovakia and Czechia. Almost half of the planned investments into new capacity in the EU are located within these three countries, which combined account for less than 15% of population and GDP.

Figure 42. Investments into new production capacity in the EU27, 2023



Source: https://www.euractiv.com/section/energy-environment/news/europes-heat-pump-valleys-take-root-in-the-east-closer-to-asia/

Reports indicate that there is room for consolidations, likely leading to efficiency gains. Even then, the industry will probably remain relatively fragmented. There is a presence of EU businesses across the value chain, with the possible exception of expansion valves mainly imported from China. One common theme, however, is that EU producers tend to be active in higher -quality and more specialised components, such as fans, plate heat exchangers, pumps, and compressors. Standardised production takes place mainly outside of the EU.[573]

The majority of inventions in the world originate from the Asia-Pacific region, with China accounting for a significant portion. However, only a small percentage of Chinese inventions are high-value patents. **In contrast, more than half of the European Union (EU) inventions are high-value patents, making the EU a leader in cutting-edge heat pump technology**.

The EU hosts a considerable number of innovating companies, with a mix of start-ups and established companies contributing to innovation. The Netherlands, in particular, stands out for having a high number of start-ups. In terms of scientific publications, Italy emerges as a leader in all types of heat pumps within the EU.[574]

Specific to *industrial* heat pumps, **the market in Europe, particularly in the 2 MW - 5 MW segment, is expected to experience substantial growth up to 2032**. Numerous European enterprises are transitioning their energy sources and mitigating greenhouse gas emissions to accommodate stringent regulations to promote energy efficiency by adopting large-scale heat pumps ranging from 2 MW to 5 MW for expansive central heating purposes. These advanced

[573] The EU Hydronic Heat Pump Manufacturing Market Assessment, provided by the European Heath Pump Association (EHPA).

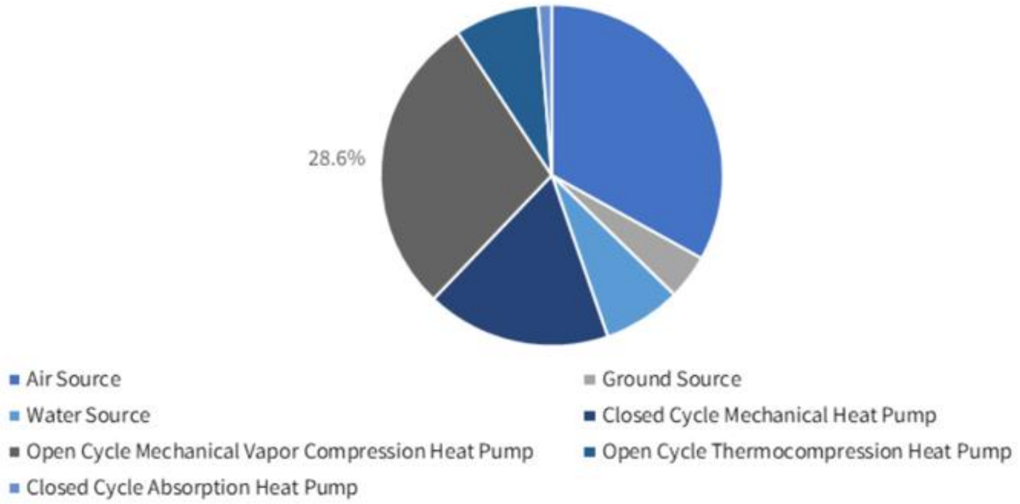
[574] Lyons, L., Georgakaki, A., Kuokkanen, A., Letout, S., Mountraki, A., Ince, E., Shtjefni, D., Joanny, G., Eulaerts, O.D. and M. Grabowska, Clean Energy Technology Observatory: Heat Pumps in the European Union – 2022 Status Report on Technology Development, Trends, Value Chains and Markets, Publications Office of the European Union, Luxembourg, 2022, doi:10.2760/372872, JRC130874

heat pump systems offer the capability to generate elevated temperatures at a significantly lower cost compared to traditional gas boilers.[575]

Market share is typically expressed by capacity installed, which does not necessarily correspond to the production of heat pump components and its assembly. The top markets in the EU27 throughout the 2019-2022 period are Germany, Spain, Austria, Finland, Sweden and Denmark.[576]

It should also be noted that various heat pump technologies or products co-exist with various adoption rates, as Figure 43 illustrates. Throughout this report, we generally make an abstract between these differences. It is important, however, that each heat pump option, and combinations thereof, have distinct features and that the right option varies from firm to firm. This confirms the observation that, especially for complex manufacturing processes, heat pump solutions are typically tailored to the needs of the client.

Figure 43. Europe industrial heat pump market share by product, 2022, as a percentage



Source: www.gminsights.com

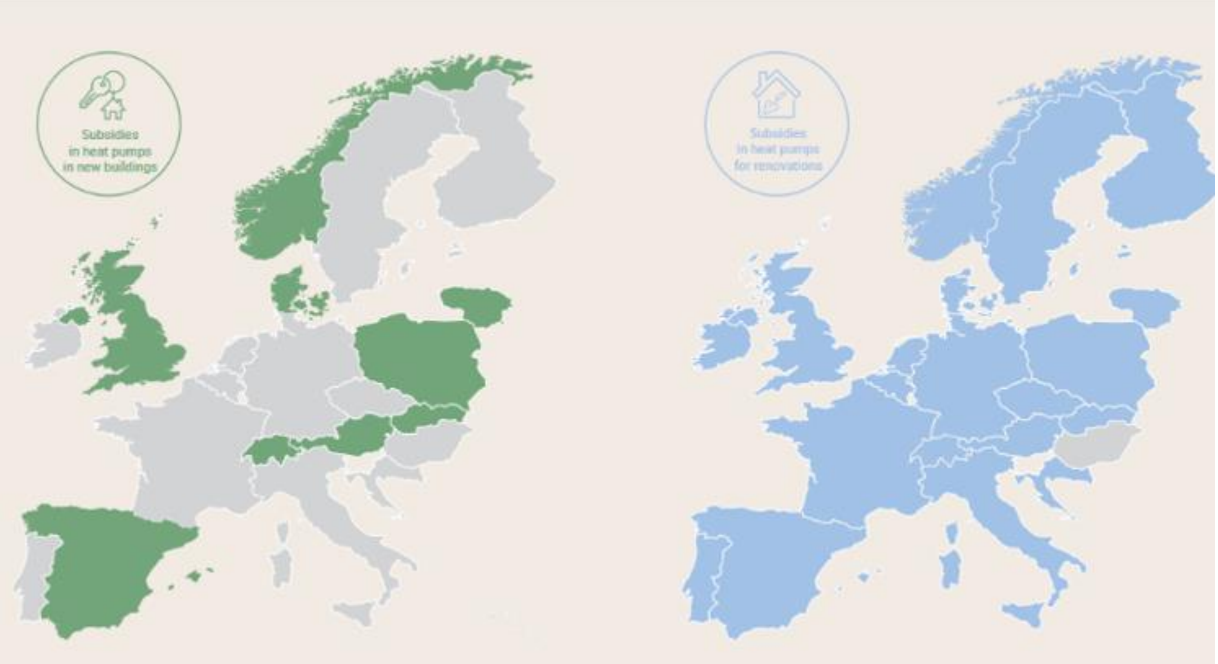
9.1.2 OSA goals and overview of relevant policy initiatives

Financial support schemes are common and typically deemed necessary to stimulate the market (at least until it reaches maturity). Grants and subsidies are, therefore, common across the EU and beyond, especially for renovation projects (see Figure 44). These support schemes vary in size, nature, technical requirements.

575 https://www.gminsights.com/industry-analysis/europe-industrial-heat-pump-market#:~:text=The%20market%20size%20of%20industrial,renewable%20energy%20solutions%20across%20industries.

576 https://www.gminsights.com/industry-analysis/europe-industrial-heat-pump-market#:~:text=The%20market%20size%20of%20industrial,renewable%20energy%20solutions%20across%20industries.

Figure 44. Subsidies for heat pump installations in Europe



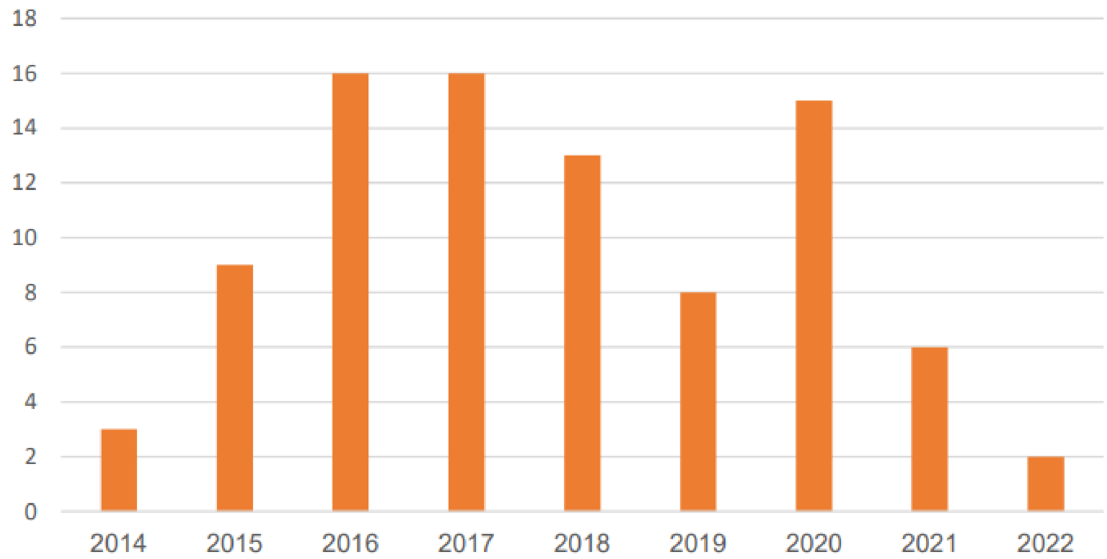
Source: https://www.pv-magazine.com/2023/03/22/residential-heat-pump-subsidies-across-europe/

Regulatory measures are also common in many EU countries, where targets that have a favourable effect on the market are set. For instance, a forthcoming legal regulation in Germany, set to take effect next year, will mandate that at least 65% of newly installed heating systems must utilise renewable energy sources. Anticipating the market shifts resulting from this regulation, the German federal government has initiated a collaborative process involving heat pump manufacturers and various industry associations, including those representing the heat pump sector, specialised trades, electrical industry, energy sector, and housing industry.[577]

The EU has been important in developing heat-pump related materials, technologies and buildings applications, and support at this level of government has been an important factor in the successful position of the region in global cutting-edge R&D. There are relevant projects originating from the European Research Council (ERC),2020 (including the Energy Efficiency in Buildings partnership and the SME instrument) and the Marie Skłodowska-Curie Actions. Figure 45 indicates that, over the 2014-2022 period, more than 80 projects dedicated to heat pumps have been set up as part of Horizon 2020.

[577] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13771-Heat-pumps-action-plan-to-accelerate-roll-out-across-the-EU/F3423380_en

Figure 45. Number of heat pump projects under Horizon 2020, 2014-2022



Source: Lyons, L., Georgakaki, A., Kuokkanen, A., Letout, S., Mountraki, A., Ince, E., Shtjefni, D., Joanny, G., Eulaerts, O.D. and M. Grabowska, Clean Energy Technology Observatory: Heat Pumps in the European Union – 2022 Status Report on Technology. Development, Trends, Value Chains and Markets, Publications Office of the European Union, Luxembourg, 2022, doi:10.2760/372872, JRC130874

9.1.3 Recommendations for future policy actions

Interviewees highlighted the **importance of policy predictability and consistency over time**. This is especially important because upfront investments can be high, and investors will be more keen to incur these costs if the returns on investment are predictable. Also, manufacturers will only make substantial investments if they are convinced of the long-term demand. Norway can function as a good example with a long-standing grant scheme that was deemed appropriate to stimulate the market without being overly generous. At the other end of the spectrum, the experience in Italy can be a cautionary tale. The so-called mega-bonus for heat pump installations introduced in 2020 was deemed overly generous and prone to fraudulent practices. The Meloni Government slashed the subsidy rate in early 2023, which led to a substantial decline in heat pump installations and resentment from beneficiaries.[578]

The industry association suggests **increasing low interest rates and loan guarantees to energy-efficient investments** using low carbon emission technologies such as heat pumps as a potential avenue to expand the market.

In order to continue playing a leading role in cutting-edge R&D, the EU should continue **fostering collaboration between industry stakeholders, research institutions, and government bodies** in its programmes.[579]

Another solution is to **provide best-practice examples of installations**.[580] This seems especially pertinent for installations for energy-intensive industries. The industrial heat pump sector was described to be at Technology Readiness Levels (TRLs) 7-9 in 2021.[581] To further

578 https://www.focus.de/finanzen/news/wie-der-superbonus-fuer-waermepumpen-italiens-heizwende-gegen-die-wand-fuhr_id_195652208.html, https://www.ft.com/content/a393a4bf-418e-418e-9905-f182914b5a7e

579 The EU Hydronic Heat Pump Manufacturing Market Assessment, provided by the European Heath Pump Association (EHPA).

580 https://www.ehpa.org/wp-content/uploads/2022/11/Large-heat-pumps-in-Europe-and-industrial-uses_2020.pdf

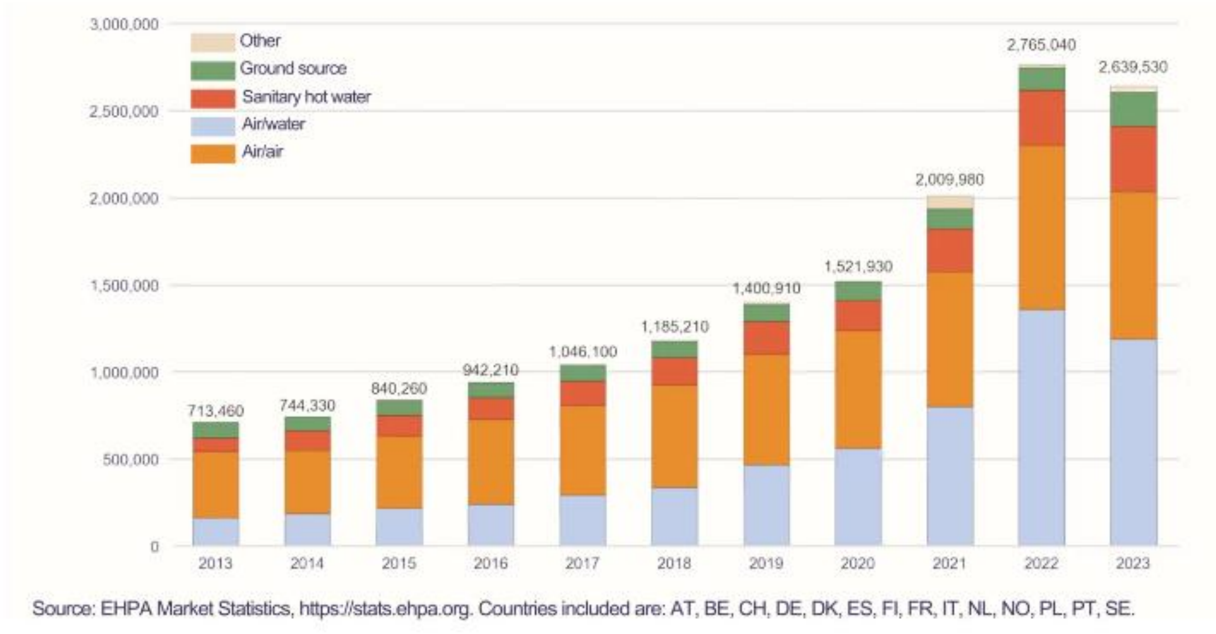
581 Lyons, L., Georgakaki, A., Kuokkanen, A., Letout, S., Mountraki, A., Ince, E., Shtjefni, D., Joanny, G., Eulaerts, O.D. and M. Grabowska, Clean Energy Technology Observatory: Heat Pumps in the European Union – 2022 Status Report on Technology Development, Trends, Value Chains and Markets, Publications Office of the European Union, Luxembourg, 2022, doi:10.2760/372872, JRC130874

develop this sector, an increase in manufacturing capacity and improved communication are needed to raise awareness of the feasibility and potential opportunities. Additionally, better market data would contribute to the growth of this industry segment.

The EU has postponed the roll-out of its Heat Pump Action Plan. The European Heat Pump Association, the EU-wide umbrella organisation for the heat pump value chain, considers that this delay caused a decline in sales in 2023, after years of strong growth (Figure 46). The development of this action plan and its adoption by the EU MS would accommodate the request for policy and regulatory predictability and consistency over the long term.

The European Commission launched a consultation process with respect to the action plan to accelerate roll-out across the EU. Several suggestions relate to increased intelligence of the potential of heat pumps and how to deploy the effectively. As one example, ENEL, a large Italian company active in the market, recommended the launch of an "EU Heat Pumps Observatory to track the progress of the adoption of Heat Pumps, of the different successful and unsuccessful models across all the value chain at Member State level and help building concerted action and best practices sharing[582]." The Clean Energy Technology Observatory (CETO) could take up this role going forward.

Figure 46. Annual sales of heat pumps for the EU14



Source: EHPA Market Statistics, https://ehpa.org. Countries included are: AT, BE, CH, DE, DK, ES, FI, FR, IT, NL, NO, PL, SE.

Other recommendations focus on the regulatory process, which is slow and cumbersome. Suggestions to streamline the permitting process for various heat pump installations and technologies are common. Pre-approved guidelines for heat pump facility locations and support for repurposing existing facilities would be welcome in this respect. This pertains especially to installations for industrial use (which, as previously mentioned, are tailored to the specificities of the firm) and access to the energy grid and Energy Integration Systems more generally. As one example, industrial-scale heat pumps hold a crucial position

[582] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13771-Heat-pumps-action-plan-to-accelerate-roll-out-across-the-EU/F3423389_en

in energy system integration by harnessing surplus heat, also known as waste heat or excess heat, derived from industrial operations and various sources like wastewater, data centers, and metro tunnels. This surplus heat can be utilised for district heating systems or incorporated into industrial processes for heating purposes, but that process is not always straightforward from a regulatory point of view. The technology should also not be overregulated, given that different solutions are needed and sufficient flexibility seems warranted.[583] Member States should also implement the Electricity Market Design directive to establish capacity remuneration mechanisms and dynamic tariffs, which can effectively reduce heat pump costs.[584]

Finally, one possible avenue is to develop quality standards for components that can be enforced and may lead to more secure and sustainable production within the EU. Such standards could effectively prevent large-scale imports from third countries that compete mainly on price, but do not offer the same quality assurances. Common technical standards that apply to at the EU-level, or standards that are more harmonised, would also create a sort of “single market,” which would benefit EU producers and drive competitiveness. The Ecodesign for Sustainable Products Regulation is a case in point.[585]

9.2 Carbon capture and storage technology

Highlights:

- SMEs (Small and Medium-sized Enterprises) have the potential to contribute significantly to CCS (Carbon Capture and Storage) initiatives by innovating capture technologies, providing specialised equipment and services, and engaging in start-up activities.
- Examples include SMEs involved in the research and development of more efficient capture systems, provision of engineering and project management services for CCS projects, and development of innovative solutions for carbon capture and utilisation.
- Start-ups in the CCS sector are emerging, raising substantial funding to set up CCS activities and explore innovative ways to utilise captured CO2.
- However, SMEs face challenges in accessing financing, navigating complex regulatory frameworks, and participating in competitive funding schemes.
- Policy implications include the need for simplified application processes, dedicated support services, capacity building initiatives, and financial incentives targeted specifically at SMEs.
- Measures to make financing more accessible to SMEs include streamlining paperwork, providing guidance on funding opportunities, offering financial incentives for R&D activities, and promoting collaborative partnerships.
- Policy makers should also consider focused funding calls aligned with the potential role of SMEs, such as developing small-scale storage sites or pilot projects.

[583] See, for example, https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13771-Heat-pumps-action-plan-to-accelerate-roll-out-across-the-EU/F3423388_en

[584] https://www.ehpa.org/wp-content/uploads/2023/06/EU-Heat-Pump-Accelerator_FINAL_June-2023.pdf

[585] https://www.ehpa.org/wp-content/uploads/2023/07/20230612-EHPA-position-NZIA.pdf

- One good practice is the establishment of dedicated funding calls, like the EU Innovation Fund's call for small-scale projects, which received significant interest from SMEs.
- Furthermore, infrastructure investments are vital for the overall market health and can open up opportunities for SMEs, even if they are not directly involved in large-scale projects.

9.2.1 Overview of the value chain, positioning of SMEs and strategic vulnerabilities

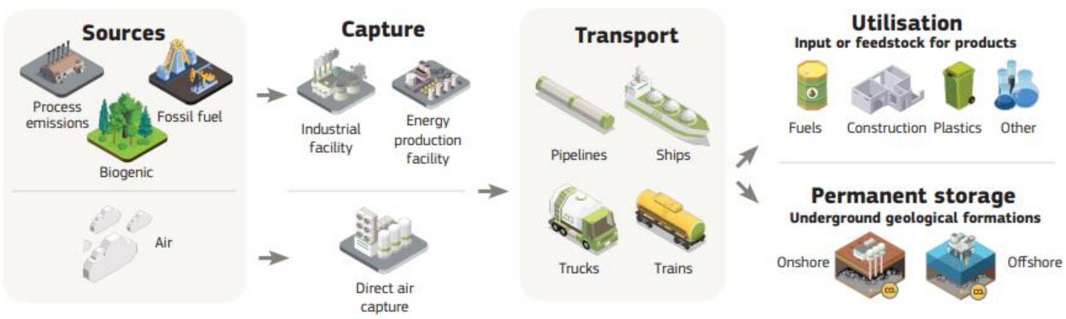
9.2.1.1 CCS - the value chain in a nutshell

Carbon capture and storage (henceforward CCS) is a set of technologies aimed at capturing, transporting and permanently storing CO2 that would otherwise be emitted into the atmosphere. In 2018, the Intergovernmental Panel on Climate Change (IPCC) concluded that CCS plays an important role in achieving global climate goals.

The left-hand side of Figure 47 depicts the emitters of carbon, in this context, energy-intensive industries. The carbon capture phase involves capturing carbon dioxide (CO2) emissions from industrial processes power plants (or directly from the atmosphere). There are various technologies for capturing CO2, including post-combustion capture, pre-combustion capture, and oxy-fuel combustion, which will not be explained in detail. Once captured, the CO2 is compressed to increase density, making transporting over long distances easier and more cost-effective. The compressed CO2 is transported via pipelines, ships, or trucks to storage sites or utilisation facilities. The compressed carbon can then be stored permanently.

As an alternative to storing the greenhouse gases, they could be used to produce products for which there is a demand from the market, for instance[586]: (i) building materials with a low or carbon-negative footprint using carbonation; (ii) non-fossil fuel by having CO2 react with hydrogen in a controlled manner or directly via CO2 electrolysis in aqueous environment; (iii) chemicals or their intermediates, such as an alternative to ethanol, methanol, syngas, ethylene, polymers and plastics."

Figure 47. The CCS value chain in pictures



Source: European Commission, Directorate-General for Energy, Industrial carbon management – Capturing, storing and using CO2 to reach our climate goals, Publications Office of the European Union, 2024, https://data.europa.eu/doi/10.2833/904398

586 https://vito.be/en/carbon-capture-use-and-storage

9.2.1.2 CCS and its role in the energy-intensive industry

CCS plays a vital role in reducing emissions from various energy industries such as steel, cement, chemicals, and refining, and there are more and more examples of companies turning to this technology to reduce their contribution to global warming.[587] EU authorities have acknowledged this method as a necessary component of Europe's climate strategy and recognise the challenges of transitioning the continent's most polluting industries to complete emission reduction by 2050.

In March 2023, the European Commission introduced the Net Zero Industry Act, which identifies CCUS as a strategic net zero technology for which scaling up manufacturing capacity is critical to reaching the EU's climate goals. Specifically, the Act proposes to set an EU-wide goal to achieve an annual CO2 injection capacity of 50 Mt by 2030, with oil and gas producers asked to contribute and set clear timelines for permitting CCUS projects.[588]

In response to the US's legislation on green industry subsidies, the European Commission incorporated CCS into its Net-Zero Industry Act (NZIA), unveiled on 16 March 2023. As per the NZIA, the EU has established a binding target to achieve a storage capacity of 50 million tonnes of CO2 annually by 2030. This carbon will be stored in designated "strategic storage sites" across the bloc, with oil and gas companies legally obligated to contribute to this objective. The specified target of 50 million tonnes annually aligns with projected industry demands, according to the European Commission.

The European Commission is developing an "EU Industrial Carbon Management Strategy," which will lay the foundation for common action at the EU level and individual member states. Actions and strategies by member states mirror the ambition at the EU level. For instance, the Dutch Government "regards CCS as an inevitable transition technology for reducing CO2 emissions in sectors where no cost-effective alternative is available in the short term."[589]

The technology is largely at the pilot stage. Denmark, for example, is a frontrunner that aims to establish itself as a leading hub for CO2 storage within North-West-Europe, leveraging its underground capacity to store CO2 captured from domestic and international sources. In 2022, Denmark, Belgium, and Flanders inked an agreement focused on facilitating the cross-border transportation of CO2 for permanent geological storage. Following suit, Denmark and the Netherlands signed a similar pact in October 2023.

Anticipated by the end of 2024, the Danish Government is set to unveil a proposal outlining the framework for cross-border infrastructure and the integration of regional transport networks dedicated to CO2 transportation. This proposal is expected to draw inspiration from the European Commission's forthcoming Industrial Carbon Management Strategy, slated for release in early 2024.[590]

9.2.1.3 Market failures

A report from the European Commission outlined market failures towards the development of CCS in the EU27,[591] namely:

[587] https://www.euractiv.com/section/energy-environment/news/heavy-industry-turns-to-carbon-capture-to-clean-up-its-act/
[588] https://www.iea.org/energy-system/carbon-capture-utilisation-and-storage
[589] https://energy.ec.europa.eu/system/files/2020-03/nl_final_necp_main_en_0.pdf
[590] https://chambers.com/legal-trends/denmarks-plan-on-co2-reductions
[591] https://www.eumonitor.eu/9353000/1/j4nvhdfcs8bljza_j9vvik7m1c3gyxp/vmajjktwgvxq

- **Challenges in establishing a viable business model**, exacerbated by substantial upfront investment requirements, the volatility of future CO2 prices, and the imperative to balance supply and demand for low-carbon products.
- **A lack of comprehensive regulatory frameworks** spanning the entire value chain, particularly concerning industrial carbon removal and specific CO2 utilization methods.
- **Early adopters engaged in constructing carbon value chains confront unique risks associated with CO2**, such as liability for leaks or the inadequacy of transportation and storage infrastructure.
- **Inadequate coordination and planning,** notably in scenarios spanning multiple jurisdictions.
- **Limited incentives for both private and public investment** to substantiate the viability of industrial carbon management initiatives.
- In addition (and not mentioned in the report), there is **insufficient information regarding the geology within Europe**, despite some EU-funded projects to bridge this knowledge gap.[592] As storage sites need to conform to specific geological conditions, this lack of data adds substantially to the costs and uncertainty of projects.
- Related to the above point, the deployment of the technology is held back in general by the **unavailability of storage sites**, especially in the EU. This is described as a necessary precondition for the market to develop.[593]

The International Energy Agency (IEA) estimates that there have been around 40 large-scale CCS projects globally in 2022, again pointing to the relative immaturity of the market. The number of projects is expected to increase substantially between now and 2030 (Figure 48). At the same time, a substantial expansion of the market is necessary to reach global targets vis-a-vis the benchmark scenario. Independent research indicates that the deployment of projects in the EU is far below the required trajectory.[594] The Commission expects these value chains to be economically sustainable and viable only by 2040, indicating a need for further government support in the meanwhile.[595]

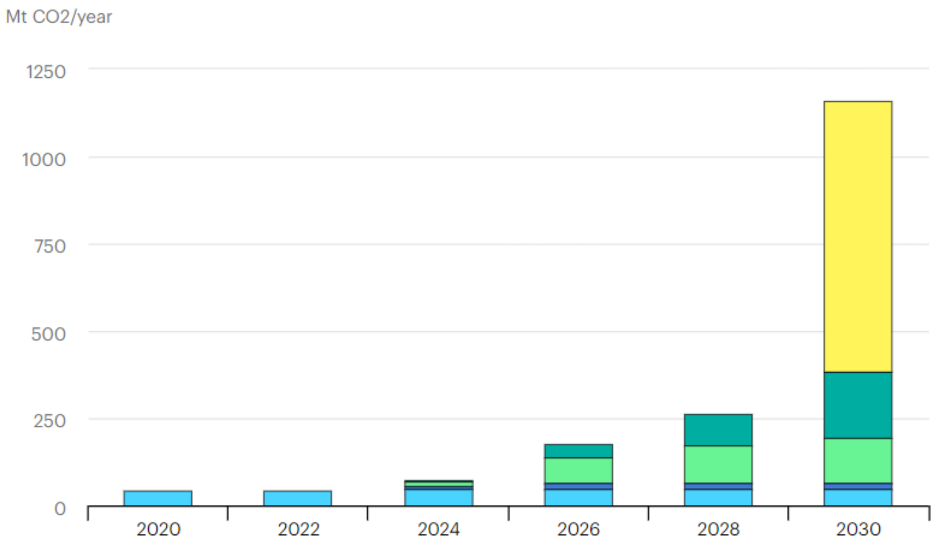
592 https://setis.ec.europa.eu/european-co2-storage-database_en

593 https://single-market-economy.ec.europa.eu/system/files/2023-03/SWD_2023_68_F1_STAFF_WORKING_PAPER_EN_V4_P1_2629849.PDF

594 https://cdn.catf.us/wp-content/uploads/2023/11/28042046/CATF_NECP_CCS_PolicyBrief.pdf

595 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52024DC0062.

Figure 48. Capacity of current and planned large-scale CO2 capture projects vs. the Net Zero Scenario, 2020-2030



Source: International Energy Agency, https://www.iea.org/energy-system/carbon-capture-utilisation-and-storage

9.2.1.4 The role of EU SMEs

The exact role of EU SMEs in CO2 capture at present varies but can include innovation in capture technologies, development of more efficient and cost-effective capture systems, and provision of specialised equipment and services for CO2 capture projects. SMEs often contribute to research and development efforts aimed at improving the performance and economics of CO2 capture technologies. Additionally, SMEs sometimes offer expertise in engineering, design, and project management for smaller-scale capture projects or for niche applications in specific industries. As one example, Pyreg GmbH is a German company created in 2009 as a spin-of of the Bingen University of Applied Sciences that provides solutions in carbon capture technologies that employed 100 people in 2023.[596]

Moreover, start-up activities in CCS have been substantial in recent years. This is a major reason why the EU is at the forefront of technological developments on the global stage.[597] One recent example is Greenlyte, a German start-up, which raised EUR 10.5 million to set up CCS activities in early 2024.[598] Sirona, based in Brussels, Belgium, is another example of a business that set up shop in 2023 with the aim of bringing research to the market. Often, these firms have substantial growth ambitions and thus the potential to ”outgrow their SME status” and not remain small. A trendsetter within Europe is Climeworks, a Swiss-based enterprise that, among other climate-related activities, explores innovative ways to utilise captured CO2, which raised around EUR 9 million in 2009 and currently employs more than 300 people.

On top of that, SMEs could potentially play a larger role in the small-scale storage of carbon. As of now, there is a tendency to concentrate storage sites in the North-West of the EU27. These storage sites are large, often able to capture 100 megatonnes of carbon dioxide or

[596] European Commission, European Innovation Council and SMEs Executive Agency, European IP Helpdesk – PYREG – From waste to value – How a small German company sets new milestones for efficient waste disposal with its revolutionary and sustainable technology – And how a sound intellectual property strategy supported starting their business, Publications Office of the European Union, 2023, https://data.europa.eu/doi/10.2826/785445

[597] https://single-market-economy.ec.europa.eu/system/files/2023-03/SWD_2023_68_F1_STAFF_WORKING_PAPER_EN_V4_P1_2629849.PDF

[598] Greenlyte raises €10.5m to reduce cost of carbon removal | Sifted

more. This model entails high transportation costs for carbon producers that are geographically far away. These costs are particularly high for smaller emitting companies and risk putting them at a competitive advantage, not only vis-a-vis firms outside of the union but also those closer to large-scale storage sites.

However, the role of SMEs within the industry is limited. A first observation is that producers of energy-intensive industries are by and large (very) large firms, as these are also typically capital-intensive in nature with large-scale production facilities. Also considering the fact that the Net Zero Industry Act encourages oil and gas companies to contribute to the goal of storing 50 million tons of CCS by 2030, the storage of CO2 is usually conducted by energy companies that are typically large as well, and a similar story holds true for the transport through pipelines, which does not lend itself that easily for smaller companies.

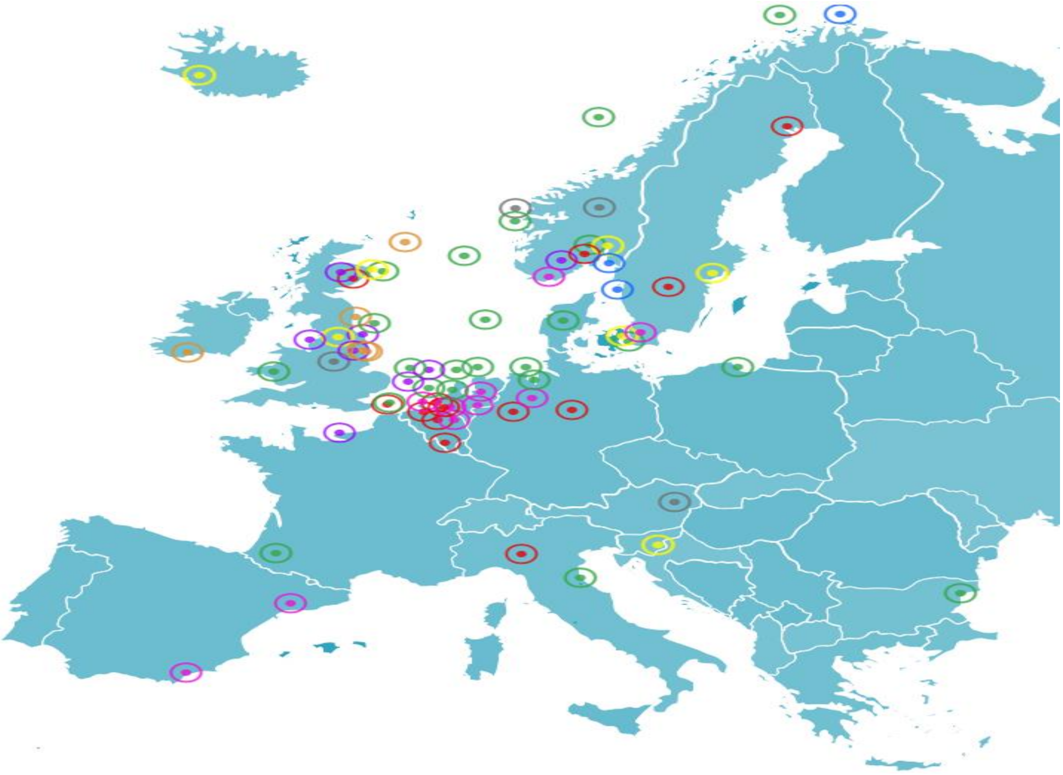
Market intelligence indicates that the number of key actors is limited, and with few exceptions, large or very large, there are around 17,000 companies worldwide active in the broader value chain.[599] Specifically, there are 186 key companies active in the market and around one in four of these key players are European or active in the field through European subsidiaries. As discussed above, there is also a substantial industrial base, which would benefit from the deployment of CSS, as well as leading role in innovation, research and development.[600]

A second observation is that market-ready projects are geographically concentrated in the North Sea area (including in Norway and the United Kingdom) and much less in the South and East of the EU. The Zero Emissions Platform tracks relevant projects that have the potential to become fully operational by 2030 (given favourable financial and regulatory frameworks). It identifies 39 projects in the EU27, many of them in a relatively early stage (Figure 49).

[599] Carbon Capture Utilisation and Storage in the European Union – 2022. Clean Energy Observatory Status Report on Technology Development Trends, Value Chains and Markets, https://setis.ec.europa.eu/carbon-capture-utilisation-and-storage-european-union_en

[600] https://single-market-economy.ec.europa.eu/system/files/2023-03/SWD_2023_68_F1_STAFF_WORKING_PAPER_EN_V4_P1_2629849.PDF

Figure 49. CSS projects in Europe



Source: https://zeroemissionsplatform.eu/about-ccs-ccu/css-ccu-projects/

The so-called Clean Ask Task Force, a non-governmental organisation, also keeps track of relevant projects and counts 100 of them in Europe, including Norway, the United Kingdom and other non-EU members.[601] The information from these projects indicates that the participating partners are, by and large, not SMEs.[602] In contrast, some advisory firms with specialised expertise that assist throughout this project, especially in the implementation phase, could be considered SMEs; however, many of them are mid-sized.[603] Other partners in such projects are research centres (technical universities) and similar organisations that are non-profit and/or government owned.

Interviewees point out that it is technically feasible to complement current plans for large-scale storage capacity with smaller storage sites geographically dispersed close to where the carbon is emitted and with much more limited capacity. In addition, the capital requirements for preparing these sites (for instance, by drilling wells) and storing the carbon are a fraction of the costs for large sites and could be operated by smaller companies. Complementing large-scale sites in the North-West of Europe with smaller sites would have the mutual benefit of helping (especially relatively small) emitters across other EU regions to achieve their climate goals in a cost-efficient manner, as well as enlarging the space for SMEs

601 https://www.catf.us/ccstableeurope/

602 This holds true for the energy-intensive companies who produce the greenhouse gasses that could be captured and then either stored or re-used, but also for many of the technology partners, such as: Lanzatech, Primetals Technology, WoodPLC, Johnson Matthey, Indaver, Indaver, Stora Enso.

603 Examples include:E4Tech, which is an specialised advisory firm with around 35 employees in 2021 and has been acquired by ERM, a much larger entity; Swerim, a Swedish industrial research institute within mining engineering, process metallurgy, materials, manufacturing engineering and applications (with 190 professionals); and EcoMission, a Hungarian firm with 13 experts that provides environmental impact analyses;

to become more active in the market of carbon storage. A final rationale for developing these sites is that, at current projections, there are not enough storage sites to meet the EU goals.[604]

9.2.2 OSA goals and overview of relevant policy initiatives

The Industrial Carbon Management Strategy (COM/2024/62) was published by the Commission on 6 February 2024 and provides the general framework at the EU level, together with the **Net Zero Industry Act** (NZIA), intending to store 50 million tons of CCS by 2030.[605]

The ETF (Emissions Trading System) has put a price on CO2 emissions and, since 2013, has incentivised the capture of CO2 for permanent storage. Recent changes include: (i) an expansion of the scope of CO2 transport for storage; (ii) the introduction of incentives for the uptake of synthetic fuels in the aviation sector; (iii) the end of a need to surrender allowances for emissions considered to have been permanently captured or utilised.

Under the Industrial Carbon Management Strategy, **the Innovation Fund** was established to move forward the knowledge frontier and bring technologies to the market. Up to now, the Innovation Fund has allocated support under the EU ETS Directive to 26 large- and small-scale CCS and CCU projects with more than EUR 3.3 billion in grants.[606] Other funding schemes at the EU level, such as Horizon 2020, the European Fund for Strategic Investments (EFSI), Programme for the Competitiveness of Enterprises and Small and Medium-sized Enterprises (COSME), European Structural and Investment Funds (ESIF) and Just Transition Fund: Part of the European Green Deal, are also relevant funding sources.

Industrial carbon management solutions have been incorporated into the draft national energy and climate plans (NECPs) of 20 Member States.[607] Many of the EU projects referred to earlier benefit from a combination of funding sources from the EU and national level. Several Member States have also developed a policy framework or national strategy. Box 40 provides more information about the French strategy as one example.

Box 40: The CCUS strategy of France

The Prime Minister of France presented on 23 June 2023, during a meeting of the National Industry Council (CNI) at Le Bourget, a strategy for Carbon Capture, Storage, and Utilisation (CCS). A consultation with industry stakeholders was open until September 29, 2023.

The document outlines a plan for deploying CCS technology, detailing timelines and targets for capturing CO2 emissions. It prioritises major industrial zones, beginning with the large industrial ports of Dunkirk, Le Havre, and Fos-sur-Mer, followed by Lacq/Southwest and Loire-Estuary, and concluding with Grand Est.

The government will introduce a support scheme through Contracts for Difference (CfD), awarded through competitive tenders, to aid industry decarbonisation projects. This will especially benefit carbon capture and storage initiatives identified through the examination of 50 potential sites. The scheme will be pre-notified to the European Commission in autumn 2023, with the first tender planned for the first half of 2024. Subsequent tender schedules will be transparently programmed to provide necessary visibility for industrialists and investors.

604 https://single-market-economy.ec.europa.eu/system/files/2023-03/SWD_2023_68_F1_STAFF_WORKING_PAPER_EN_V4_P1_2629849.PDF

605 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2024%3A62%3AFIN&qid=1707312980822

606 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52024DC0062

607 https://energy.ec.europa.eu/document/download/6b89e732-fea4-480b-9d2e-cf64de90247e_en?filename=Communication_-_Industrial_Carbon_Management.pdf

A regulatory framework for CO2 transport infrastructure will be established, overseen by the Energy Regulatory Commission (CRE). Given the necessity for risk-sharing between the state, CO2 transport infrastructure operators, and industrial users, various measures, including state guarantees against volume risks, will be implemented.

Diversification of CO2 storage options is emphasised, with the government aiming to develop storage capacities in France to ensure sovereignty and competitiveness in carbon capture for French industry. Exploration campaigns and CO2 injection tests at pilot sites will commence by the end of 2023, with initial tests scheduled for 2024/2025. These storage capacities may particularly target former hydrocarbon exploitation areas. The government will also promote the adoption of CCUS technology through an information and exchange campaign to foster local acceptability.

Moreover, the government will continue to form partnerships with European neighbours to secure markets for industrial sites. The document highlights the potential for CO2 valorisation as an alternative to storage, particularly for decarbonising sectors like aviation and maritime.

One policy lever to realise this ambition are the The Low-Carbon Industrial Zones (ZIBaC) Call for Projects, an initiative led by the French Environment and Energy Management Agency (ADEME). The GOCO2 is a joint project that is underway. It is currently the largest decarbonisation project in Western France in terms of captured and transported CO2 volume. It could ultimately transport and export up to 4 million tonnes per year of CO2 by 2050, accounting for over 75% of industrial emissions in the Greater West of France by that time.

Sources: https://www.conseil-national-industrie.gouv.fr/actualites/consultation-sur-la-strategie-nationale-ccus, https://www.grtgaz.com/medias/communiques-de-presse/lancement-goco2

9.2.3 Recommendations for future policy actions

While the CCS industry in the United States is experiencing growth, largely due to the Biden administration's offer of a tax credit of USD 85 per tonne of CO2 stored, the EU has opted for a different approach. It believes that the ETS will incentivise polluters to adopt CCS to avoid carbon costs. **The ETS imposes increasingly higher prices on carbon emissions, prompting polluting companies to reduce or eliminate CO2 emissions. The EU could complement its current approach with tax credits or other more direct support measures to kickstart the market and** progressively raise the price levels within the ETS.

In addition, **the EU Industrial Carbon Management Strategy needs to be fleshed out**, especially because the CCS market would probably entail the export of CO2 from EU producers with few facilities towards EU MS with excess storage facilities.

Aside from issues related to storage and transportation, there is also a need for **a common regulatory approach** and EU support for funding schemes. Storage facilities are likely to remain operational after 2030, even up to 2050. Coupled with high and uncertain upfront costs, viable business models need regulatory certainty and predictability. At the moment, there are lingering concerns that the operationalisation of this industry would prolong the use of fossil fuels, which limits the political support and, in turn, makes the bureaucratic procedures in accordance with Directive 2009/31/EC, such as getting the right permits, unnecessarily complex and cumbersome.[608] The EU has made improvements in this area. Nonetheless, a

[608] https://single-market-economy.ec.europa.eu/system/files/2023-03/SWD_2023_68_F1_STAFF_WORKING_PAPER_EN_V4_P1_2629849.PDF

recent position paper from SMEUnited, an association at the EU level, calls for greater clarity about how to make the ambitious plans more concrete.[609]

Moreover, due to the relative immaturity of the market and uncertainties about the viability of a profitable business model, **direct support measures such as tax credits, grants, and low-interest loans may be advised, as well as public funding for R&D activities**.

At the same time, there is considerable uncertainty concerning what technology will prevail and become commercially viable.[610] This calls for a t**echnology-agnostic approach that avoids governments picking winners** and thus allows access to government support for a relatively broad set of technologies.

The Innovation Fund and other support schemes are major catalysts for developing the market, particularly in making the transition from science to a commercially viable business plan. At the same time, participating in these support schemes is time-consuming and requires specific expertise that reportedly represents a major barrier for smaller firms to participate. Any measures to make these sources of financing more accessible to SMEs are welcome in this respect. This can take the form of:

- A simplified application process with a focus on bureaucratic hurdles and streamlining paperwork.
- Dedicated support services, with guidance on funding opportunities, assistance with proposal writing, and access to networking events or matchmaking activities.
- Capacity building initiatives specifically designed for SMEs in skills related to CCS technologies, project management, and proposal development.
- Financial incentives or grants specifically targeted at SMEs to offset the costs associated with participating in Horizon projects or developing CCS technologies. This could include funding for research and development, demonstration projects, or pilot studies.
- The encouragement of collaborative partnerships which stimulate a mix of different partners, including smaller businesses and start-ups.
- Focused funding calls that are aligned with the possible role SMEs can play, for instance to develop small, modular storage sites, close to emitting companies which are less capital intensive, or pilot projects.
- Promotion and awareness of funding calls through targeted marketing, outreach campaigns, and dissemination of information through relevant channels.

One good practice is the dedicated First Innovation Fund call for small-scale projects, with 232 applications received for the EUR 100 million EU funding for small clean tech projects. Around half of them were for CCS projects and related activities.[611]

In addition, **to make these investments more accessible to SMEs, they need to be scaled up considerably to realise the EU-level goals**.[612] A consideration is that infrastructure projects, for instance, allowing carbon dioxide transportation over long distances, are vital to the health of the overall market and benefit all actors involved. In other words, these

[609] https://www.smeunited.eu/admin/storage/smeunited/smeunited-position-nzia.pdf

[610] Sievert K, Schmidt T, Steffen B: Considering technology characteristics to project future costs of direct air capture, Joule, 01.03.2024, doi: external page10.1016/j.joule.2024.02.005call_made

[611] https://climate.ec.europa.eu/news-your-voice/news/first-innovation-fund-call-small-scale-projects-232-applications-eur-100-million-eu-funding-small-2021-03-12_en

[612] https://www.europarl.europa.eu/RegData/etudes/STUD/2020/652717/IPOL_STU(2020)652717_EN.pdf

investments will open up opportunities for start-ups and smaller companies, even if SMEs are not directly involved.

9.3 Electrolysers

Highlights:

- Electrolysers are essential for the green transition, enabling emissions reduction through processes like carbon capture and hydrogen production.
- European SMEs play a pivotal role in electrolyser production and deployment, driving innovation and competitiveness in the market.
- The Important Project of Common European Interest (IPCEI) supports SMEs by providing funding and opportunities to participate in electrolyser projects.
- Despite Europe's significant share in global electrolyser manufacturing, SMEs face challenges from competitors in Asia and America, with Chinese rivals undercutting prices of European manufacturers and the US Government providing massive subsidies.
- By prioritising SME participation and implementing supportive policies, the EU can accelerate its decarbonisation goals. This approach fosters innovation, drives economic growth, and maintains Europe's leadership in sustainable technology development. Policy initiatives must streamline regulations and offer financial incentives to enhance SME involvement and strengthen Europe's position in the electrolyser market.
- Additionally, financial support mechanisms such as tax breaks or grants can further incentivise SME engagement in electrolyser projects.
- Collaboration between SMEs, policymakers, and other stakeholders is crucial for advancing electrolyser technology and achieving carbon neutrality.

9.3.1 Overview of the value chain, positioning of SMEs and strategic vulnerabilities

9.3.1.1 Electrolysers and their role in the green transition

Electrolysers play a crucial role in generating low-emission hydrogen by utilising electricity to separate water into hydrogen and oxygen. Electrolysers thus offer a solution for significant CO2 emitters to mitigate their carbon dioxide emissions through a process known as "electrolytic carbon capture and utilisation" (eCCU). This innovative method employs electrolysers to capture CO2 emissions from industrial operations and convert them into valuable products such as synthetic fuels, chemicals, and feedstocks. Electrolysers facilitate this process in several ways:

- **Carbon Capture**: Integrating electrolysers into industrial facilities allows for the direct capture of CO2 emissions from exhaust streams of combustion processes, such as those found in power plants, cement production, steelmaking, and chemical manufacturing. By capturing CO2 at the source, electrolysers help large emitters reduce their emissions footprint and comply with regulatory standards.
- **Hydrogen Production**: Utilising renewable electricity, electrolysers split water molecules into hydrogen (H2) and oxygen (O2) through electrolysis. This hydrogen can

then act as a clean energy carrier for various industrial processes, substituting fossil fuels and consequently reducing CO2 emissions related to combustion. By utilising renewable electricity for hydrogen production, electrolysers support large emitters in decarbonising their energy supply and diminishing their dependency on carbon-intensive fuels.

- **Syngas Production**: Electrolysers can also generate syngas, a blend of hydrogen and carbon monoxide (CO), by electrolysing a mixture of water and CO2. Syngas serves as a versatile feedstock for producing synthetic fuels like hydrogen-enriched natural gas (H2NG), ammonia, methanol, and synthetic hydrocarbons. By utilising CO2 captured from industrial emissions as a primary material, electrolysers empower large emitters to convert their emissions into valuable products, thus reducing their overall carbon footprint.
- **Carbon Utilisation**: Electrolytic carbon capture and utilisation (eCCU) technologies enable significant CO2 emitters to convert captured CO2 into high-value products suitable for commercial applications. These products include renewable fuels for transportation, chemicals for industrial processes, and construction materials for buildings. By transforming CO2 emissions into valuable commodities, electrolysers offer an economic incentive for large emitters to mitigate their emissions and transition to more sustainable practices.

It should be noted that while electrolysers are one of the primary methods used to produce green hydrogen, other emerging techniques are under development, such as biomass gasification and thermochemical water splitting. **At the same time, it is the most mature and promising renewable hydrogen production technology currently on the market**. For that reason alone, the manufacturing capacity of electrolysers is poised to accelerate everywhere globally, including within the EU27.[613]

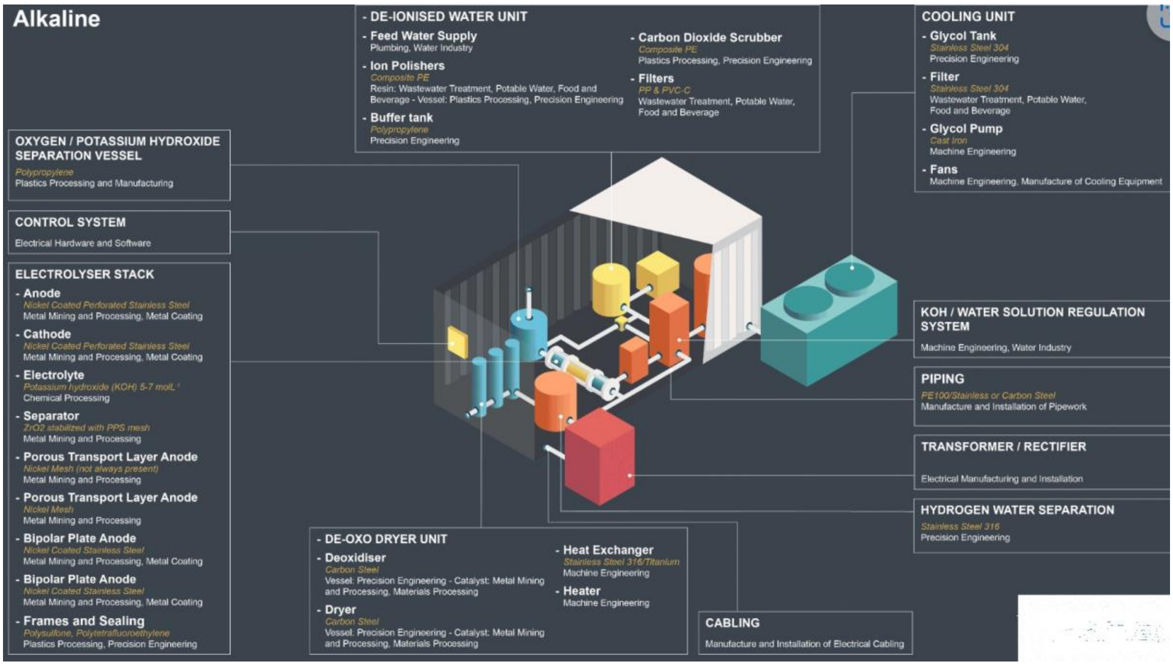
Finally, there are different electrolysis technologies, with alkaline electrolysis, proton exchange, membrane (PEM) electrolysis, and solid oxide electrolysis cells (SOECs) prominent ones.[614] We will not systematically distinguish between various sub-technologies in this section, unless when relevant.

The production of electrolysers is also a complex process involving many components, which demand substantial amounts of materials from outside the EU. Figure 50 illustrates (for one technology). For the sake of brevity, we do not expand on the various components that are part of the manufacturing process.

613 https://joint-research-centre.ec.europa.eu/jrc-news-and-updates/water-electrolysis-and-hydrogen-growing-deployment-prospects-europe-and-beyond-2023-11-24_en

614 https://iea.blob.core.windows.net/assets/9e3a3493-b9a6-4b7d-b499-7ca48e357561/The_Future_of_Hydrogen.pdf

Figure 50. The production of alkaline electrolysers



Source: https://www.gov.scot/publications/assessment-electrolysers-report/pages/3/

The overall value chain can be distinguished alongside the following activities:

- Raw materials extraction;
- Manufacturing of components;
- System integration and installation;
- Operation and maintenance;
- End-of-life services.[615]

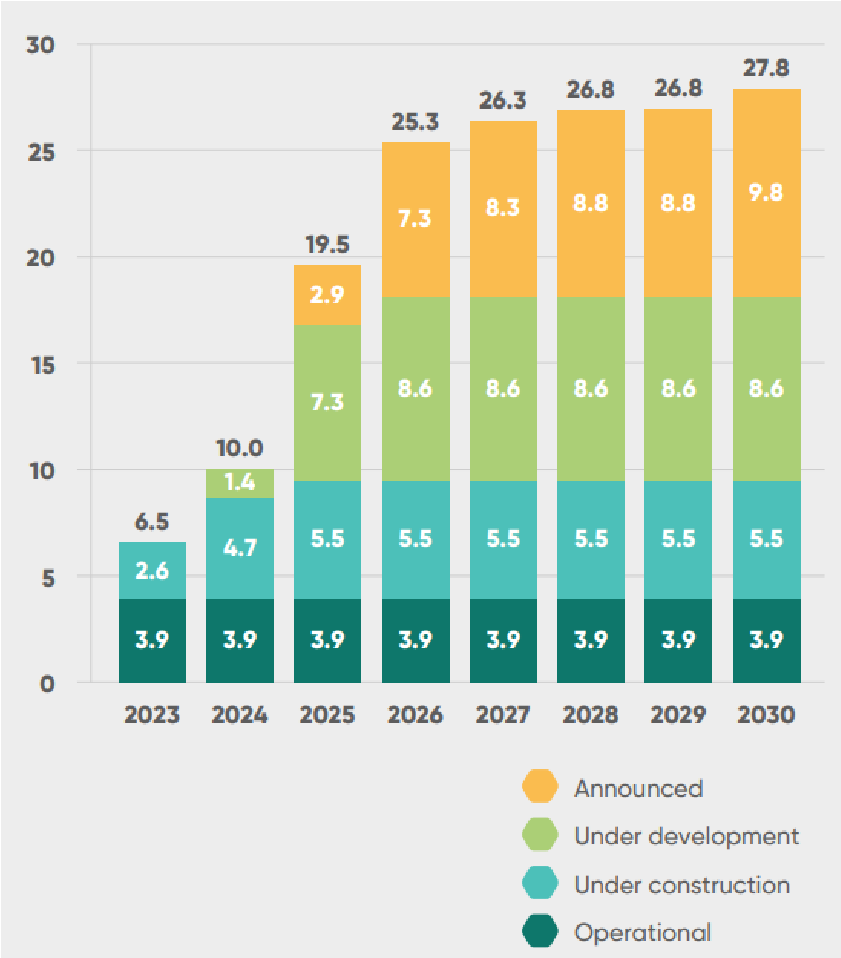
9.3.1.2 The role of EU SMEs in the production and deployment of electrolysers

Over recent years, the capacity for electrolysis dedicated to hydrogen production has been steadily increasing. In Europe, encompassing the EU, EFTA nations, and the United Kingdom, the collective installed capacity of electrolysis expanded from 85 MW in 2019 to 162 MW by August 2022, as per estimates. Short-term projections suggest this capacity could climb to a minimum of 191 MW and potentially reach an optimistic 500 MW by the conclusion of 2023. Furthermore, plans indicate that by the end of 2025, a substantial 1 371 MW of electrolysis capacity is scheduled to become operational across Europe. By 2030, 140 GW of electrolysis capacity could be installed.[616]

[615] https://www.gov.scot/publications/assessment-electrolysers-report/

[616] https://joint-research-centre.ec.europa.eu/jrc-news-and-updates/water-electrolysis-and-hydrogen-growing-deployment-prospects-europe-and-beyond-2023-11-24_en

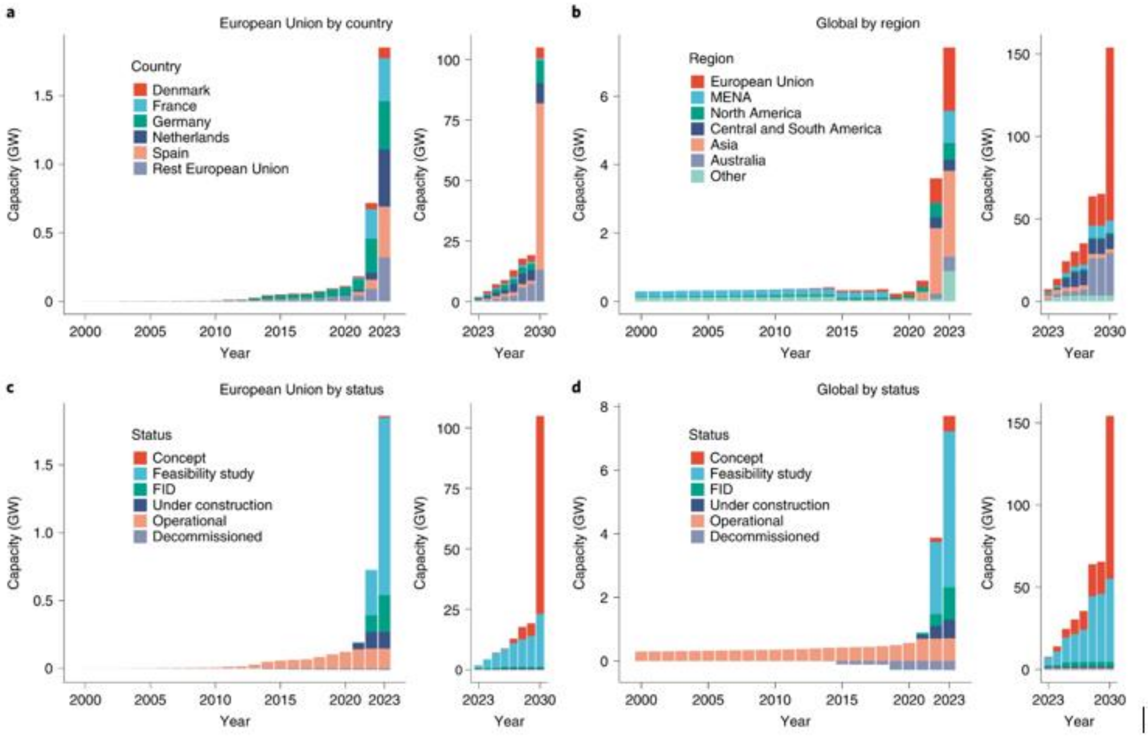
Figure 51. Development of electrolyser manufacturing capacity in Europe for the period 2023-2030 (GWel/year)



The European Commission expects investment needs of between EUR 50 million and EUR 75 million between 2022 and 2030 to reach the target.[617] Figure 52 confirms the relatively strong position of the EU in terms of electrolysis capacity, the countries that are expected to be at the forefront and the added capacity that is expected.

617 https://single-market-economy.ec.europa.eu/system/files/2023-03/SWD_2023_68_F1_STAFF_WORKING_PAPER_EN_V4_P1_2629849.PDF

Figure 52. Historical development and future announcements of electrolysis projects

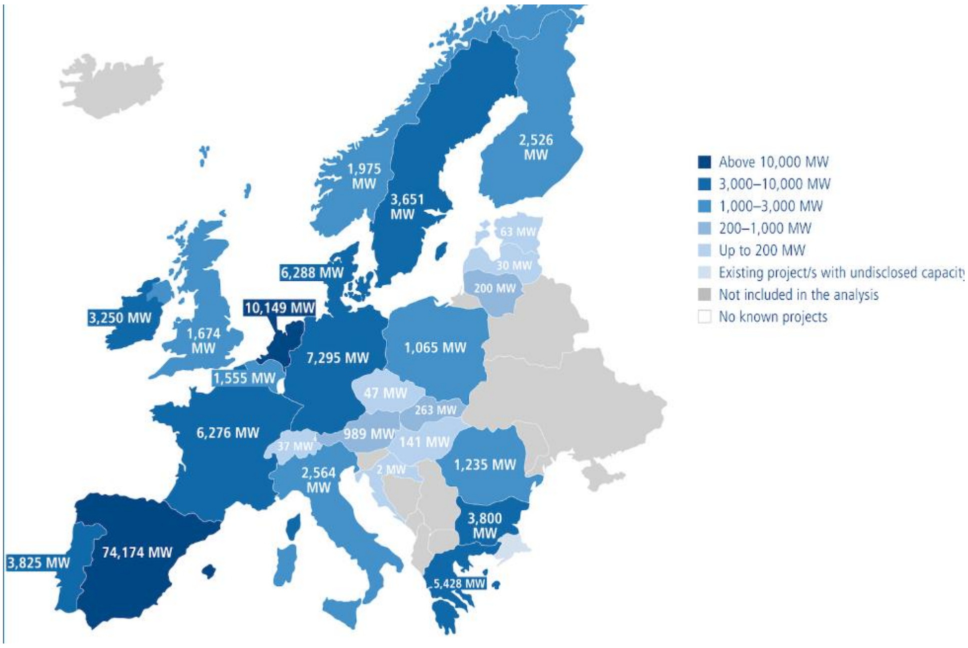


Odenweller, A., Ueckerdt, F., Nemet, G.F. *et al.* Probabilistic feasibility space of scaling up green hydrogen supply. *Nat Energy* **7**, 854–865 (2022). https://doi.org/10.1038/s41560-022-01097-4

Other sources confirm that **the market is expected to expand in different European regions and countries**. While Spain is forecasted to represent a major focal point of activities within the EU27, other member states are also in the process of raising capacity levels (see Figure 53). Typically, electrolyser manufacturing facilities are situated in close proximity to deployment sites, hence the presence of industry across the EU27. This is because large electrolyser installations need to be customised according to the specific requirements of each project. The economic viability of shipping full electrolyser systems is not anticipated due to their substantial weight, indicating that the assembly activities are hard to outsource (compared to the production of individual components).[618] In addition, they are often concentrated where there is abundant affordable renewable energy, for example, from offshore wind farms, which is one reason why Denmark of the Netherlands is relatively well positioned.

[618] https://single-market-economy.ec.europa.eu/system/files/2023-03/SWD_2023_68_F1_STAFF_WORKING_PAPER_EN_V4_P1_2629849.PDF

Figure 53. Planned electrolyser capacity additions by country, 2022-2030, MW



Source: https://www.ees-europe.com/market-trends/generation-capacity-for-green-hydrogen-rising-rapidly

The EU 27 counts for around 20-30% of global electrolyser production, depending on the estimate, with China being the world leader (especially for alkaline electrolysers, the most mature technology, and where Chinese producers enjoy a considerable price advantage).[619] Other estimates put Europe (including non-EU27 member states, particularly the United Kingdom) in a more favourable light, with an estimated 60% of global electrolyser manufacturing capacity and 40% of electrolysis capacity. In Europe, electrolyser manufacturers have a robust presence ranging from major industry leaders to smaller actors. In the Netherlands, as one example, around 150 manufacturing companies are active in the market, producing (sub) components for electrolysers, with a select few that assemble complete electrolyser systems, the so-called Original Equipment Manufacturers.[620] However, a complete overview of relevant actors within Europe and a breakdown by size class appear absent. Interviews indicate that smaller companies have a strong presence, especially in the more novel technologies.

These companies benefit from strong research facilities across the region. Currently, Europe leads in technology innovation, holding about 40% of patents in the field, with a particularly strong position in PEM technology.[621] An alternative estimate is less positive but still underlines that the EU is active in this area (see Figure 54). Finally, data indicate that European companies are increasing their share of patents globally.[622]

---

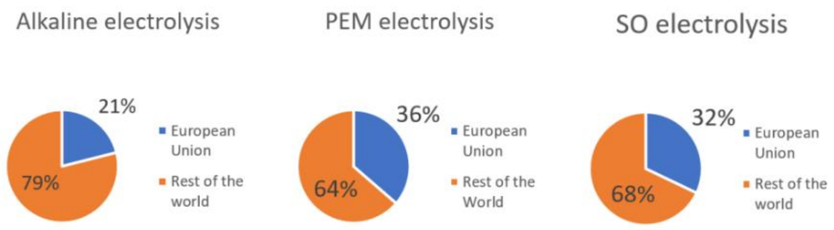
619 https://single-market-economy.ec.europa.eu/system/files/2023-03/SWD_2023_68_F1_STAFF_WORKING_PAPER_EN_V4_P1_2629849.PDF and https://www.hydrogeninsight.com/electrolysers/europe-on-track-to-deliver-21gw-green-hydrogen-electrolyser-factory-capacity-by-2025/2-1-1476501

620 https://ispt.eu/media/The-race-for-a-position-in-the-global-electrolysis-market-ISPT-FME-TNO.pdf

621 https://www.swp-berlin.org/10.18449/2022C57/

622 https://single-market-economy.ec.europa.eu/system/files/2023-03/SWD_2023_68_F1_STAFF_WORKING_PAPER_EN_V4_P1_2629849.PDF

Figure 54. Total worldwide publications and patents from 1996 to 2019, data provided by the FCH-JU



Source: https://www.euractiv.com/section/energy/news/europe-china-battle-for-global-supremacy-on-electrolyser-manufacturing/

Interviews highlight European firms' clear technological advantage in research and development in high-temperature electrolysis. This technology is still largely unproven, with a small number of pilots taking place, but it has substantial potential advantages compared with more established alternatives. In particular, is it more efficient in theory, allowing for less energy loss and thus lower prices.[623]

There is ample opportunity to scale-up. For instance, Green Hydrogen Systems, a Danish company, is a leading provider of standardised, modular, pressurised alkaline electrolysers. It started as an R&D company in 2007, developing the pressurised alkaline electrolyser technology, but has since 2017 moved into the commercialisation phase. In 2020, it had 20 employees. In 2024, more than 300 people worked at the company, thus outgrowing the SME status. Sunfire, a German company, was founded in 2010. In early 2024, it employed around 650 workers and was gearing up for another expansion with a loan of €100 million from the European Investment Bank (EIB) and €215 million in a Series E equity.[624]

SMEs dominate largely unproven technologies, such as high-temperature electrolysis, where they drive innovation with (technical) universities and research organisations. Some of these firms also become active in manufacturing. As the technology matures, the role of larger businesses becomes more prominent. For one, small innovative companies sometimes "outgrow their SME status" when successful through organic growth or because large companies buy them. In addition, interviews indicate that large companies show an increasing interest in electrolysis technology and production in a more mature stage of development, for example, for PEM and especially alkaline electrolysis and may set up their own electrolysis units, both for R&D and for production. For example, Siemens and Bosch, two very large companies from Germany, have both set up sizeable activities in this area.[625]

European companies' once-dominant position in electrolyser manufacturing technology is gradually diminishing, with competitors from Asia and America rapidly closing the gap. While the EU currently leads in electrolyser design, this supremacy faces challenges from China, which commands the largest share of planned global electrolyser manufacturing capacity. Moreover, the Inflation Reduction Act in the United States is attracting additional investment towards expanding manufacturing capabilities. This poses a tangible risk to a key technology essential for the EU's energy-intensive industry decarbonisation goals, as more favourable investment environments abroad may prompt EU manufacturers to prioritise scaling up operations in China or the United States to capitalise on burgeoning renewable

---

[623] https://www.sciencedirect.com/topics/engineering/high-temperature-electrolysis#:~:text=The%20advantages%20of%20the%20high,to%20high%2Dtemperature%20fuel%20cells.

[624] https://tech.eu/2024/03/05/sunfire-raises-over-500m-to-boost-european-s-green-hydrogen-economy/

[625] https://www.siemens-energy.com/global/en/home/products-services/product-offerings/hydrogen-solutions.html and https://bosch-hydrogen-energy.com/

hydrogen markets there. A major concern is whether European firms can close the price gap with their Chinese rivals, which can produce electrolysers at one-fourth of the cost in the EU.[626]

9.3.2 OSA goals and overview of relevant policy initiatives

Policies related to developing and deploying electrolysers are typically part of broader schemes to develop (green) hydrogen. The Important Project of Common European Interest (IPCEI) in the hydrogen technology value chain is a case in point.[627]

The IPCEI, approved by the Commission, focuses on advancing research, innovation, and industrial deployment within the hydrogen technology value chain. Electrolysers, pivotal in hydrogen generation, are a central component of this initiative. SMEs, alongside larger companies, are essential contributors to the IPCEI, participating in projects aimed at developing innovative electrolyser technologies.

These projects aim to enhance electrolysers' performance, safety, and environmental impact while optimising cost efficiencies. By advancing electrolyser technology, the IPCEI aims to accelerate the transition to clean energy in sectors such as mobility. SMEs, with their agility and innovation capacity, play a significant role in driving these advancements forward.

The IPCEI's focus on electrolyser technology underscores its commitment to fostering breakthrough innovations that will enable energy-intensive industries to transition to cleaner alternatives and reduce reliance on fossil fuels. Through collaboration with SMEs and other stakeholders, the IPCEI seeks to unlock the full potential of hydrogen technology for a sustainable future.

One concrete IPCEI proposal aims to construct a research and innovation facility dedicated to manufacturing electrolysers, along with two industrial-scale test production lines planned for Belgium and France. One facility is set to be situated in Seraing, Belgium, focusing on stacking parts, joints, and assembly parts. The second facility will be located in Aspach, Alsace, France, dedicated to the individual manufacture of electrolysis cells, involving processes such as cutting, welding, and nickel plating, particularly for large diameter parts. The goal is to achieve a production capacity of 1GW per year by 2030. The investment for Belgium is estimated at EUR 103 million.[628]

In 2023, more than 50 countries globally had adopted a hydrogen strategy, road map or similar document with electrolysers playing a major role.[629] Many EU countries, as well as the EU itself, have done so as well. Within the EU, the Repower EU Plan which builds on the Hydrogen Strategy sets targets of electrolyser capacity in 2024 and in 2030.

Another example is the United Kingdom's adoption of its hydrogen strategy in 2021.[630] It outlines the government's plan to develop a hydrogen economy as part of its efforts to achieve net-zero carbon emissions. It focuses on utilising hydrogen as a clean energy source for various sectors, including industry, transportation, and heating. The strategy includes initiatives to produce low-carbon hydrogen, establish hydrogen production hubs, invest in research and development, support hydrogen infrastructure, and promote international collaboration. It aims

[626] https://single-market-economy.ec.europa.eu/system/files/2023-03/SWD_2023_68_F1_STAFF_WORKING_PAPER_EN_V4_P1_2629849.PDF

[627] https://ec.europa.eu/commission/presscorner/detail/en/ip_22_4544

[628] https://single-market-economy.ec.europa.eu/system/files/2023-03/SWD_2023_68_F1_STAFF_WORKING_PAPER_EN_V4_P1_2629849.PDF

[629] https://joint-research-centre.ec.europa.eu/jrc-news-and-updates/water-electrolysis-and-hydrogen-growing-deployment-prospects-europe-and-beyond-2023-11-24_en

[630] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1175494/UK-Hydrogen-Strategy_web.pdf

to unlock the potential of hydrogen to decarbonise the economy and address climate change while creating new economic opportunities and supporting job growth. Electrolytic production plays a major role in this strategy, with plans to move from small-scale facilities to ever-production at critical mass. Spain is one example of an EU country that has set particularly ambitious targets. In October 2020, the Ministry for Ecological Transition and the Demographic Challenge (MITECO) approved the "Hydrogen Roadmap: a commitment to renewable hydrogen". The roadmap defines 60 specific measures which are divided into the following 4 blocks:

"Regulatory: At present, hydrogen production is considered an industrial activity, thus the roadmap suggests modifying the classification of on-site renewable hydrogen production and developing policies to facilitate the development of direct electricity lines dedicated to renewable hydrogen production. It also attaches a green tax to the positive externality of producing green hydrogen.

Sectoral: These include measures for the different components of the hydrogen value chain. Establishing a statistical system for hydrogen data, development of particular financial instruments for green hydrogen industry and creation of hydrogen "valleys" are some of the key aspects. Furthermore, this block describes promoting the consumption of renewable hydrogen in the transport sector.

Cross-cutting: Support for the cross-cutting instruments that establish suitable technical and technological framework for the fulfilment of the defined objectives. The Hydrogen Roadmap aims to be a dynamic instrument that is updated every three years in order to correctly evaluate the degree of success.

Promotion of R&D: Exclusive lines of financing will be provided for projects in the renewable hydrogen value chain. The role of the National Hydrogen Centre ("CNH2") as a leading public R&D centre will be strengthened."[631]

The Spanish Government has provided financial stimulants to develop the market. In 2023, grants are awarded to seven initiatives to integrate large electrolysers in industrial environments in five autonomous communities for a total of EUR 100 million.[632]

In 2022, a Joint Declaration was signed between Commissioner Breton and 20 industry CEOs, outlining an agreed target by electrolyser manufacturers in Europe to increase their manufacturing capacity by tenfold to 17.5 GW per year. **It also includes Commission actions aimed at establishing a supportive regulatory framework, facilitating access to finance, and promoting efficient supply chains**. These actions include:

- Ensuring that regulations governing the production of renewable hydrogen support a rapid and cost-effective expansion of the market for renewable hydrogen and its production in Europe.
- Adoption of a recommendation and legislative proposal on expedited permitting for renewable energy projects, including those related to renewable hydrogen.
- Prioritising the assessment of State aid notifications for hydrogen projects.
- Commitment by electrolyser manufacturers to submit only high-quality project proposals fully aligned with climate targets and the REPowerEU ambition.
- Collaboration with the European Investment Bank (EIB) to streamline the financing of electrolyser manufacturing and deployment projects.

631 https://gh2.org/countries/spain

632 https://www.lamoncloa.gob.es/lang/en/gobierno/news/paginas/2023/20230605_renewable-hydrogen-aid.aspx

- Establishment of an 'Electrolyser Partnership' to unite electrolyser manufacturers and suppliers of components and materials within the existing structures of the European Clean Hydrogen Alliance.
- Joint commitment to integrate the value chain, diversify, and address the dependency on key raw materials and chemicals within the framework of the EU industrial strategy.

9.3.3 Recommendations for future policy actions

Several technologies are ready to be deployed on a large scale, particularly Alkaline and Proton Exchange Membrane electrolysers.[633] As these are relatively novel technologies, the supply chains within Europe are nascent and could be further integrated.[634]

One recommendation is thus to "connect the dots" within the eco-system, which is the goal of 'Electrolyser Partnership' as part of the European Clean Hydrogen Alliance. The plan is to unite electrolyser manufacturers and suppliers of components and materials within the alliance's current framework. Financial institutions, including the EIB, will be encouraged to join and participate in this partnership.

Another recommendation is **to ensure sufficient input**. While this is not unique to electrolysers, it seems particularly relevant in this context, given their large number, any of which can put a break into the ambitious plans to scale up production. Inputs that are in short supply for electrolyser production include rare earth metals like platinum, iridium, and ruthenium used as catalysts for electrodes, titanium for construction due to its corrosion resistance, membrane materials with high conductivity for PEM electrolysers, nickel for electrodes in alkaline electrolysers, and carbon fibre for structural reinforcement. Raw material partnerships with third countries are thus particularly important.[635]

European electrolyser manufacturers pledge substantial investments in research, development, and innovation (R&D&I), collaborating with both private entities and academia. The Commission and its Member States can play a crucial role in support of these activities. Research programs like the Horizon Europe Clean Hydrogen Partnership are crucial.[636]

Related to the previous point, there is a discrepancy between the level of ambition and the financial means. In particular, there is a shortage of private sector investment. It is, therefore, crucial **to develop financial support instruments that unlock activities from the private market and, crucially, do not crowd out private sector activities**. These include co-investment schemes, public-private partnerships, tax breaks for equity investors, loan guarantees and so on. For this specific value chain, the European Investment Bank (EIB) could potentially step up efforts to underwrite loans for electrolyser manufacturers.[637]

Industry actors note that "*gaps persist in the regulatory framework and the speed of implementation lags (definitions and certification, binding target formulation, etc.), holding back future hydrogen producers and off-takers from making firm commitments.*[638]" It is well acknowledged that regulatory compliance is more costly and burdensome for smaller firms, so **any efforts to streamline and harmonise the regulatory framework within the EU would particularly spur their involvement in the value chain**.

---

633 https://joint-research-centre.ec.europa.eu/jrc-news-and-updates/water-electrolysis-and-hydrogen-growing-deployment-prospects-europe-and-beyond-2023-11-24_en
634 https://ec.europa.eu/docsroom/documents/50014
635 https://ec.europa.eu/docsroom/documents/50014
636 https://ec.europa.eu/docsroom/documents/50014
637 https://ec.europa.eu/docsroom/documents/54935
638 https://ec.europa.eu/docsroom/documents/54935

The EU mandates that 40% of key climate infrastructure, including electrolysers, should be sourced from European manufacturers through its public procurement policies and directives. The legal basis for this requirement lies in EU procurement regulations, particularly Directive 2014/24/EU on public procurement. This directive, which is transposed into national legislation, allows EU member states to impose certain criteria, **including environmental considerations, in public procurement procedures. This can be considered a potent tool to drive OSA that is relatively market-friendly and technology-agnostic**. Given the already strong position of EU firms in the electrolysers sector, the target could be raised further.[639]

European hydrogen electrolyser manufacturers are urging the EU to implement "Made in Europe" local content requirements. They believe these measures are necessary to shield the domestic industry from less expensive Chinese imports, which benefit from substantial subsidies. According to the manufacturers, such policies would help ensure the competitiveness and sustainability of the European electrolyser industry. Additionally, interviewees in the article noted that while local content requirements are common around the world, they are notably absent in the EU, which puts European manufacturers at a disadvantage in comparison to their global counterparts. In other words, this is not perceived as an unfair advantage but rather as a way to level the playing field and avoid European subsidy schemes and other support measures overly benefiting foreign companies.[640]

Regulations can also favour domestic production. PEM electrolyser manufacturers benefit from Brussels' adoption of renewable hydrogen production standards. To qualify as "renewable," electrolysers must be powered by dedicated solar or wind installations, with compliance initially monitored monthly and transitioning to hourly checks by 2030. This requirement favours PEM electrolysers, where EU firms are at the forefront (in contrast with alkaline electrolysers, whose market is dominated by Chinese firms), as they can adapt to production windows efficiently.[641]

[639] https://www.hydrogeninsight.com/electrolysers/europe-on-track-to-deliver-21gw-green-hydrogen-electrolyser-factory-capacity-by-2025/2-1-1476501

[640] https://www.hydrogeninsight.com/electrolysers/european-hydrogen-electrolyser-makers-call-upon-eu-to-introduce-made-in-europe-requirements-to-protect-them-against-cheaper-chinese-imports/2-1-1396297

[641] https://www.euractiv.com/section/energy-environment/news/how-us-hydrogen-rules-could-decide-fate-of-eus-electrolyser-industry/

10 OSA and SMEs in the energy renewables ecosystem

10.1 Wind energy

Highlights:

- The wind energy value chain encompasses project management, manufacturing, operation, and decommissioning, with European manufacturers holding a strong market position, particularly those based in Germany, Denmark, Spain, and the Netherlands.
- SMEs play a vital role in supplying components in the lower tiers of the supply chain, contributing to the robustness of the wind energy sector's supply chain.
- Employment opportunities in the wind energy sector are substantial, with concentrations in coastal regions creating jobs for both large manufacturers and smaller SMEs.
- Challenges exist, notably regarding the supply of rare earth elements and permanent magnets, predominantly controlled by China.
- Policy initiatives such as the New Circular Economy Action Plan aim to reduce dependency on critical raw materials, promoting sustainability and resilience.
- The Net-Zero Industry Act and the REPowerEU Plan focus on accelerating wind energy deployment and strengthening supply chains, with specific measures to support SMEs.
- Recommendations include supporting SMEs in innovation, easing access to finance, and addressing raw material dependencies to ensure the sector's long-term competitiveness and sustainability. Moreover, collaboration between governments, industry, and research institutions is essential to implement effective policies and support SMEs in navigating challenges and seizing opportunities in the wind energy sector

10.1.1 Overview of the value chain, positioning of SMEs and strategic vulnerabilities

Wind turbines transform kinetic energy into mechanical energy, which in turn is converted by generators into electricity. Figure 55 provides an overview of the wind energy value chain, starting from project management, manufacturing, to operation and decommissioning, which has feedback loops via reuse and recycling technologies back into the manufacturing stage. According to RystadEnergy[642] **Europe is one of the regions in the world with the largest manufacturing capacity for wind power components**. The EU27 has interconnected value chains within and across Member States. Also, the Free Trade Agreements with non-EU countries foster trade relations. The major Member States with wind power manufacturing capacity are Germany, Denmark, and Spain. For the offshore wind segment, the Netherlands

[642] RystadEnergy (2023) The State of the European Wind Energy Supply Chain. A “what-would-it-take” analysis of the European supply chain’s ability to support ambitious capacity targets towards 2030. April 2023, 56 pp accessible from The State of the European Wind Energy Supply Chain | WindEurope

ranks among the top Member States. The experience from Denmark provides good practices that could be adopted elsewhere.

Box 41: Lessons learned from Denmark's success in the wind energy sector.

Denmark and some other countries in the EU are windy and, therefore, have a competitive advantage. Its location next to the North Sea also represents a rationale for developing offshore wind farms. At the same time, Denmark's success in wind energy innovation can be attributed to a combination of visionary policy decisions, consistent support for research and development, and proactive industry development measures. These policies created an environment that enabled the growth of the wind energy sector and positioned Denmark as a global leader in renewable energy. It should be noted that

IDanish policymakers consistently integrated wind energy into their broader energy policy framework as early as the 1980s. This approach ensured that wind energy was seen as a central component of Denmark's energy strategy rather than merely a supplementary option. This long-term vision provided stability and direction for the wind energy sector.

Denmark also implemented policies that provided continuous incentives for research and development in wind energy technology. These policies encouraged investment in R&D, driving innovation and technological advancements in the wind energy sector. Support and incentives were available to wind turbine manufacturers, developers, and associated industries, and encouragement was given to collaborate across different subsectors.

Denmark implemented policies to facilitate the planning and siting of wind turbines. By addressing concerns related to environmental impact, land use, and community acceptance, these policies helped ensure the successful deployment of wind energy projects across the country and, once the companies become successful domestically, also abroad.

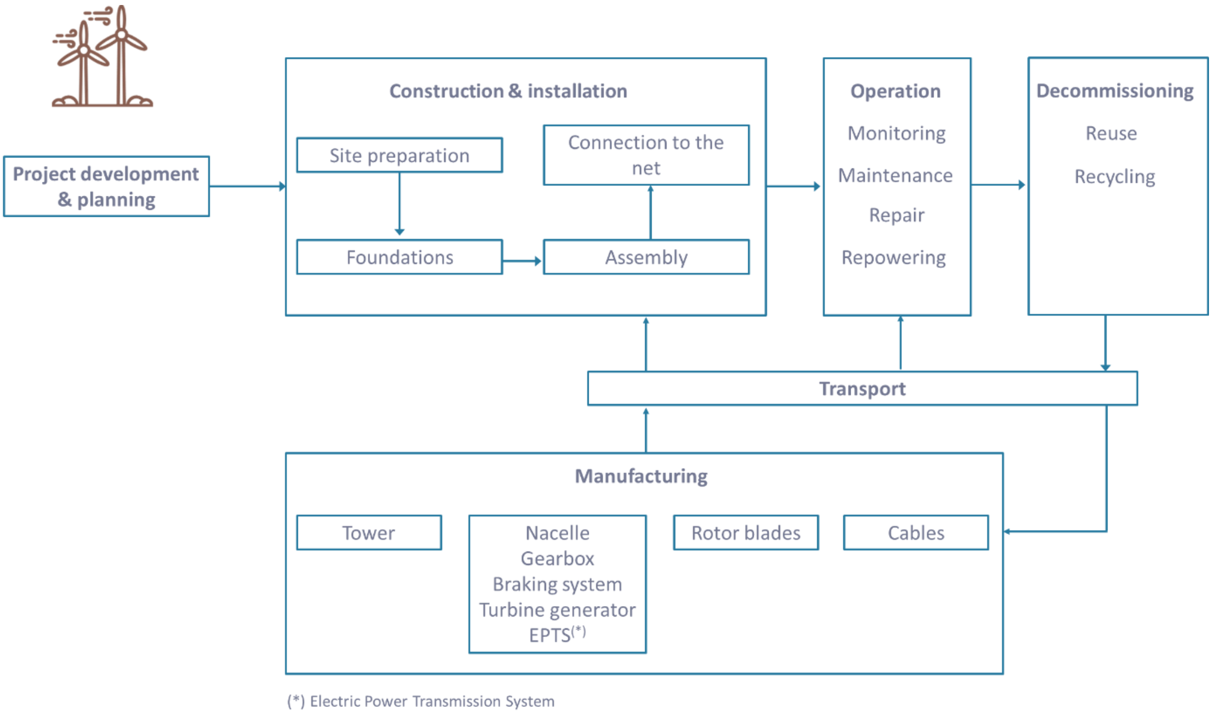
Denmark embraced the principle of citizen ownership of wind turbines, which garnered broad political support and strengthened local acceptance of wind energy projects. This approach empowered communities to participate in and benefit from the expansion of wind energy infrastructure.

Source: https://academic.oup.com/book/44441/chapter/376662269?

Production of wind energy installations is close to the demand where these assets are installed. Hence, in terms of spatial distribution across the EU, installed capacity corresponds roughly to manufacturing capacity. Port facilities are important, especially for offshore installations and trade. European original equipment manufacturers (OEM) have had a relatively strong market position in the last decade. The latest JRC report[643] on wind energy in the EU indicates that among the 10 major OEM in the world, the EU manufacturers accounted for about one-third of the global market (see Figure 56).

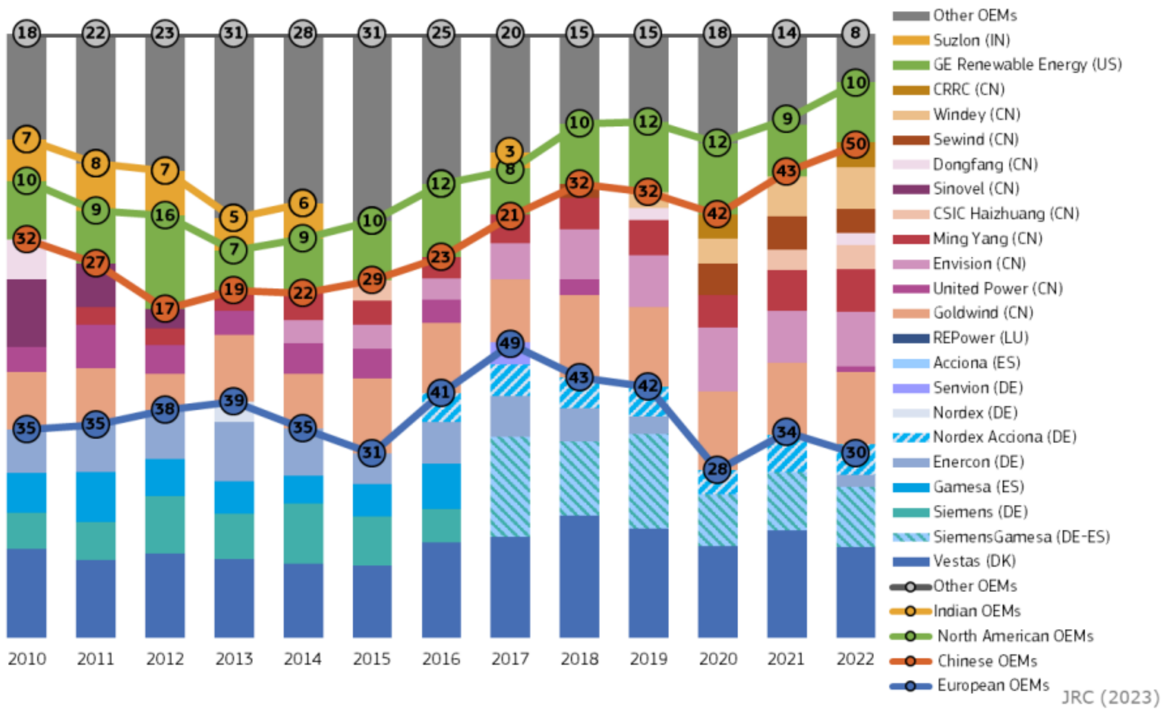
[643] Tapoglou, E., Tattini, J., Schmitz, A., Georgakaki, A., Długosz, M., Letout, S., Kuokkanen, A., Mountraki, A., Ince, E., Shtjefni, D., Joanny Ordonez, G., Eulaerts, O.D. and Grabowska, M., Clean Energy Technology Observatory: Wind energy in the European Union - 2023 Status Report on Technology Development, Trends, Value Chains and Markets, Publications Office of the European Union, Luxembourg, 2023, doi:10.2760/618644, JRC135020.

Figure 55. Schematic overview of the wind energy value chain



Source: authors, based on Bilsen et al. (2016)[644] and RystadEnergy (2023)

Figure 56. Market share of the top OEMs in wind energy over the period 2010-2022 aggregated by country of origin for onshore and offshore deployments



Source: Tapoglou et al. (2023) p. 43

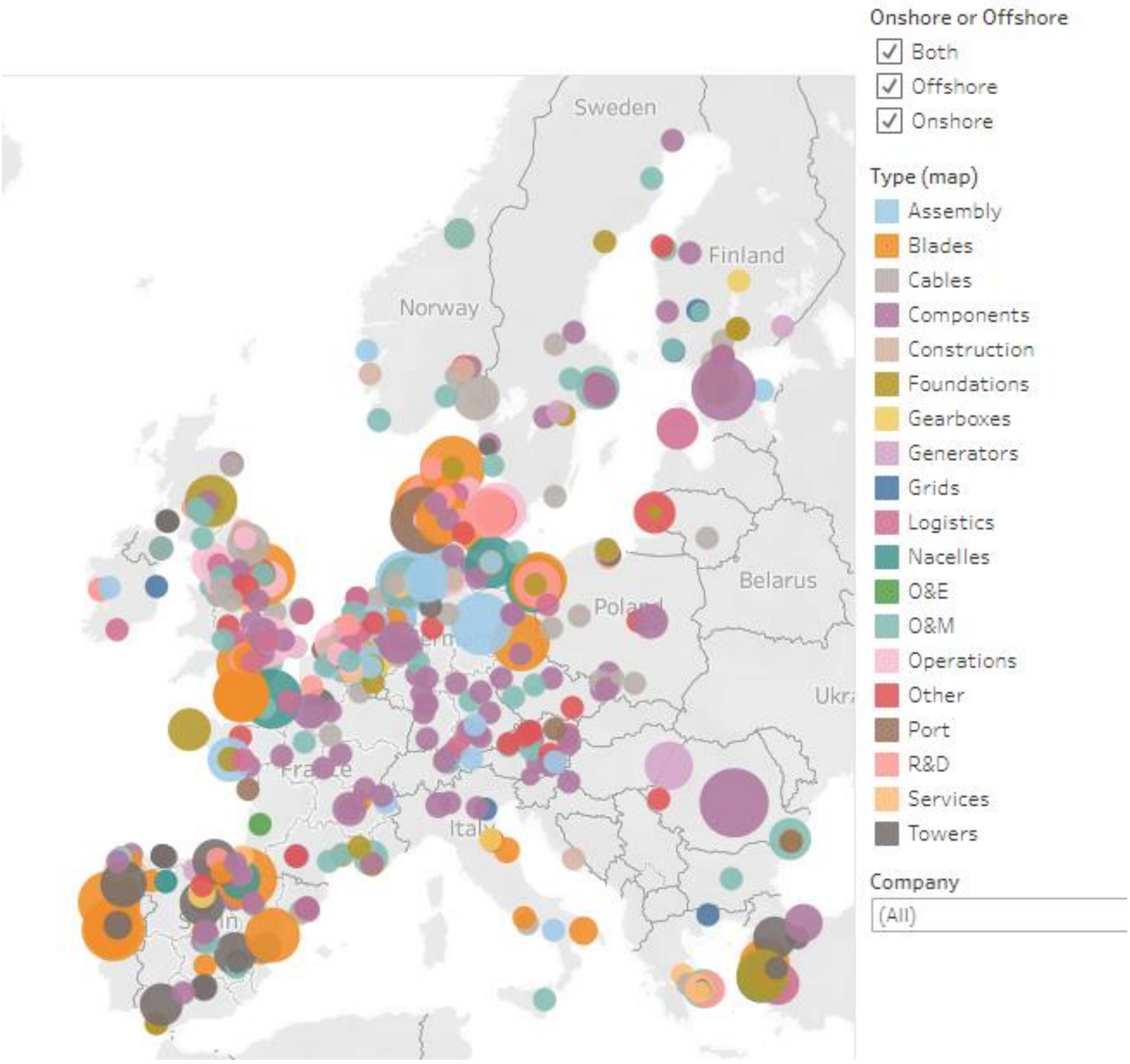
644 Bilsen, V., Debergh, P., Greeven, S., Gehrke, B., John, K., Lemmel, A., (2016) Identifying Levers to unlock Clean Industry – Background Report, Brussels, 349 pp. Identifying levers to unlock clean industry - Publications Office of the EU (europa.eu)

OEMs rely on Tier 2 and Tier 3 suppliers that are specialised in particular products. While the Tier 1 manufacturers are large companies, within the Tier 2 and Tier 3 segments of the wind energy value chain, more SMEs are present. Although we do not have precise data on the size distribution over the value chain components, Figure 57 provides a geographical distribution across Europe for all wind energy value chains. The value chain covers virtually all MS, with concentrations in Germany, Spain, Denmark, as well as the Netherlands and France.

According to a recent study,[645] **about 240,000 to 300,000 direct and indirect jobs are created by the wind energy sector**. Offshore wind would amount to 77,000 jobs. About one-fourth of the EU's direct jobs are with turbine and component manufacturers, 15% of service providers, 8% of developers, and 3% of manufacturers of offshore structures. The concentration of employment is in the Member States which borders the Atlantic Ocean, the North Sea, and the Baltic Sea. More of the employment in Europe is mainly related to component manufacturing and cable production.

[645] Tapoglou, E., Tattini, J., Schmitz, A., Georgakaki, A., Długosz, M., Letout, S., Kuokkanen, A., Mountraki, A., Ince, E., Shtjefni, D., Joanny Ordonez, G., Eulaerts, O.D. and Grabowska, M., Clean Energy Technology Observatory: Wind energy in the European Union - 2023 Status Report on Technology Development, Trends, Value Chains and Markets, Publications Office of the European Union, Luxembourg, 2023, doi:10.2760/618644, JRC135020

Figure 57. Supply chain map for all value chain components in wind energy in Europe – location and employment



Source: WindEurope – Wind supply chain regional map (accessed 5-3-2024)
Note: Circle size represents employment; all companies registered in WindEurope's map application

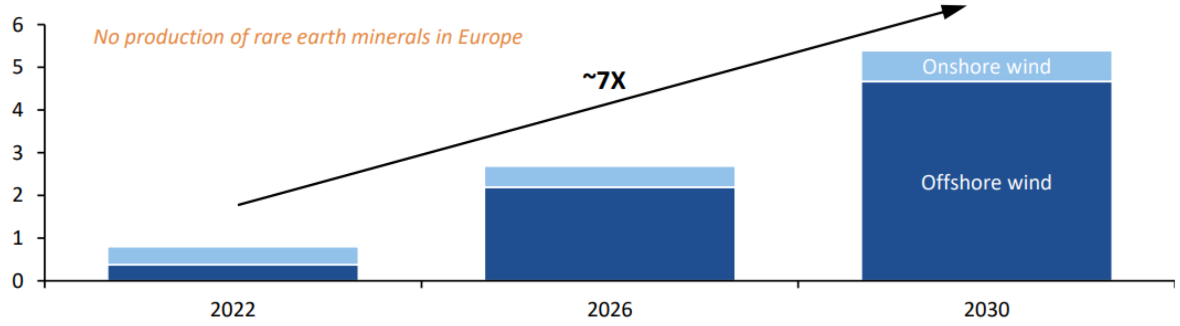
Although the EU has well-established OEMs in the wind energy sector, such as Vestas, Siemens-Gamesa, Enercon, Nordex Acciona, Senvion, REPower, for certain parts of the value chain, EU manufacturers are dependent on supplies from elsewhere. It has been shown[646] that the most critical bottleneck and, therefore, the highest supply risks exist in the rare earth elements[647] and the permanent magnets supply chain. Permanent magnets are essential for achieving high efficiency and performance. Other raw materials include niobium, which is used in steel alloys for towers, and boron, which is used in magnets. Currently, China dominates the rare earth elements market. It covers the entire value chain of permanent magnets, from extraction, refinement, alloying, to magnet manufacturing. Given its strong

[646] Tapoglou, E., Tattini, J., Schmitz, A., Georgakaki, A., Długosz, M., Letout, S., Kuokkanen, A., Mountraki, A., Ince, E., Shtjefni, D., Joanny Ordonez, G., Eulaerts, O.D. and Grabowska, M., Clean Energy Technology Observatory: Wind energy in the European Union - 2023 Status Report on Technology Development, Trends, Value Chains and Markets, Publications Office of the European Union, Luxembourg, 2023, doi:10.2760/618644, JRC135020

[647] Rare earths for these magnets include dysprosium (Dy), neodymium (Nd), praseodymium (Pr) and terbium (Tb).

position in rare earth elements production, China also strongly influences the market prices for these materials. RystadEnergy (2023) indicates that if Europe is to reach its wind energy targets by 2030, the demand for rare earth elements is expected to grow seven-fold (Figure 58)

Figure 58. Estimated demand for rare earth elements from the European onshore and offshore wind sector (thousand metric tons) according to RystadEnergy (2023)



RystadEnergy (2023), p. 48

Improved material management in Europe, as promoted by the New Circular Economy Action Plan in combination with the EU Raw Materials Initiative and the Critical Raw Materials Act will alleviate the dependency. According to a study by the European Environment Agency, by 2030, about 4.75 million tonnes of concrete, metals, and composites will be produced annually[648]. The authors assessed that 90% of the materials, e.g., steel, copper, aluminium, cast iron, concrete, can be recycled. **Errore. L'origine riferimento non è stata trovata.** gives an overview of the average material composition across various wind turbine types. In terms of weight, the critical raw materials represent only a small fraction of the total material weight per GW. However, they are an essential part of wind energy technology, which, in the short term, cannot be substituted by less critical materials for the EU. Critical raw materials in permanent magnet generators improve the business case for profitable recycling, despite the lack of industrial scale or commercial process to recycle rare earth elements from end-of-life products. [649]

[648] Graulich, K., Bulach, W., Betz, J., Dolega, P., Hermann, C., Manhart, A., Bilsen, V., Bley, F., Watkins, E., Stainforth, T. (2021) Emerging waste streams - Challenges and opportunities, Freiburg, February 2021, 89 pp, accessible from https://www.oeko.de//fileadmin/oekodoc/EEA_emerging-waste-streams_final-report.pdf and EEA https://www.oeko.de//fileadmin/oekodoc/EEA_emerging-waste-streams_final-report.pdf accessed 13-03-2024.

[649] Kaya, M. (2024) An overview of NdFeB magnets recycling technologies in Current Opinion in Green and Sustainable Chemistry, vol. 46, April 2024 accessible from An overview of NdFeB magnets recycling technologies - ScienceDirect Moreover, rare earth recycling techniques are still at the lower end of the technology readiness scale as witnessed by the multiple EU-funded research projects. Recent examples related to permanent magnets for wind energy applications are NEOHIRE, SUSMAGPRO, PASSENGER, REESilience, and REEPRODUCE. NEOHIRE: NEOdymium-Iron-Boron base materials, fabrication techniques and recycling solutions to HIghly REduce the consumption of Rare Earths in Permanent Magnets for Wind Energy Application | NEOHIRE | Project | Fact sheet | H2020 | CORDIS | European Commission (europa.eu); SUSMAGPRO: Sustainable Recovery, Reprocessing and Reuse of Rare-Earth Magnets in a Circular Economy (SUSMAGPRO) | SUSMAGPRO | Project | Fact sheet | H2020 | CORDIS | European Commission (europa.eu); PASSENGER: Pilot Action for Securing a Sustainable European Next Generation of Efficient RE-free magnets | PASSENGER | Project | Fact sheet | H2020 | CORDIS | European Commission (europa.eu); REESilience: Resilient and sustainable critical raw materials REE supply chains for the e-mobility and renewable energy ecosystems and strategic sectors | REESilience | Project | Fact sheet | HORIZON | CORDIS | European Commission (europa.eu); REEPRODUCE: Dismantling and recycling Rare Earth Elements from End-of-life products for the European Green Transition | REEPRODUCE | Project | Fact sheet | HORIZON | CORDIS | European Commission (europa.eu)

Table 14. Material usage estimates in tonnes per GW for different wind turbine types.

Material	Range [t/GW]
Concrete	243 500 - 413 000
Steel	107 000 - 132 000
Iron (cast) (Fe)	18 000 - 20 800
Glass/carbon composites	7 700 - 8 400
Copper (Cu)	950 - 5 000
Zinc (Zn)	5 500
Polymers	4 600
Aluminium (Al)	500 - 1 600
Manganese (Mn)	780 - 800
Chromium (Cr)	470 - 580
Nickel (Ni)	240 - 440
Neodymium (Nd)	12 - 180
Molybdenum (Mo)	99 - 119
Praseodymium (Pr)	0 - 35
Dysprosium (Dy)	2 - 17
Terbium (Tb)	0 - 7
Boron (B)	0 - 6

Source: Graulich et al. (2021) p. 47. The ranges were estimated based on Carrara et al. (2020)[650]

The EU is also well-placed when it comes to startup activities. StartUs Insights, an independent company that gathers intelligence on startup activities around the globe, identifies 745 startups in this sector, making Europe, including the United Kingdom, a global hotspot for startups (Figure 59). *Table* 15 lists several initiatives that underscore the diverse ways European startups are advancing the wind energy sector, combining technology and sustainability to meet future energy needs.

Table 15. Key initiatives by start-ups in the wind energy sector

Start-up(s)	Project description
KiteKraft and Skypull	They are transforming wind turbine technology by developing innovative designs. KiteKraft is focused on flying turbines that significantly reduce the need for building materials, thereby lowering the carbon footprint of wind energy. Skypull offers a cost-effective solution by using a high-altitude flying system that captures wind energy more efficiently.
Aerones and SkyVisor	In the realm of automation and robotics, companies like Aerones and SkyVisor are enhancing the safety and efficiency of wind turbine operations. Aerones conducts robotic inspections and maintenance on turbine blades, while SkyVisor deploys autonomous drones for detailed turbine inspections.
Turbit Systems	Turbit Systems is incorporating artificial intelligence to facilitate predictive maintenance, which optimizes turbine performance and minimizes downtime.

[650] : Carrara S., Alves Dias P., Plazzotta B. and Pavel C., Raw materials demand for wind and solar PV technologies in the transition towards a decarbonised energy system, EUR 30095 EN, Publication Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-16225-4, doi:10.2760/160859, JRC119941, accessible from http://publications.jrc.ec.europa.eu/repository/bitstream/JRC119941/rms_for_wind_and_solar_published_v2.pdf

Modvion	Modvion is leveraging eco-friendly materials such as laminated wood to construct wind turbine towers, which not only reduces CO2 emissions but also costs.
Airturb	Airturb has introduced a small, silent wind turbine suitable for residential use, addressing both aesthetic and environmental concerns.

Source: https://www.startus-insights.com/innovators-guide/wind-energy-trends/ and https://www.eu-startups.com/2022/12/10-european-wind-energy-startups-that-will-blow-you-away/

Figure 59. Startup activity in wind energy: A heat map, 2023

Source: https://www.startus-insights.com/innovators-guide/wind-energy-trends/

10.1.2 OSA goals and overview of relevant policy initiatives

Wind power is the most important renewable energy source for producing electricity. In 2022, its share in total renewable energy production for electricity was 37.5%. Hence, wind energy is essential for reaching the net-zero climate goals by 2050. The Net-Zero Industry Act (EU 2023) identifies onshore and offshore wind energy as one of the eight technologies that are strategic for reaching the EU's decarbonisation targets and one of the five technologies earmarked as key technologies.[651]

Renewable energy policies have been gradually developed over time with strong momentum after the approval of the Green Deal.[652] Figure 60 provides an overview of the major EU renewable energy policy initiatives, strategies and legislation since 2019.

Although the main focus of the various energy-related policy initiatives, laws, and strategies has been obtaining a net-zero CO2 economy by 2050, already from the onset, the

[651] The key legislation of the EU's renewable energy policy is the new Renewable Energy Directive (EU) 2023/2413 (RED III) . This directive established a target of 42.5% share for renewable energy in the final energy consumption of the EU by 2030. The original RED, adopted on April 23, 2009, (RED I) established that 20% of the EU's gross final energy consumption must come from renewable energy sources by 2020. As part of the Clean Energy for All Europeans Package the revision of the Renewable Energy Directive (RED II) which entered into force December 2018, established a binding target of at least 32% of gross final energy consumption by 2030. Hence over time from 2009 to 2023 the binding target has been gradually increased from 20 % by 2020 to 42.5% by 2030.

[652] For a historical overview of the EU's renewable energy policy before the EU Green Deal we refer to Solorio, I, Bocquillon, P. (2017) EU Renewable Energy Policy: A Brief Overview of its History and Evolution, June 2017 in Solorio, I. and Jörgens, H. (2017) A Guide to EU Renewable Energy Policy Comparing Europeanization and Domestic Policy Change in EU Member States, Edward Elgar. The chapter is accessible from (3) (PDF) EU Renewable Energy Policy: A Brief Overview of its History and Evolution (researchgate.net).

competitiveness of the EU economy has been an important prerequisite and condition to reaching the net-zero ambitions. For instance, the Energy Union Strategy's fifth goal aims to support breakthroughs in low-carbon clean energy technologies and improve competitiveness [653]. The European Strategic Energy Technology Plan (SET Plan) has included competitiveness since its inception in 2007. However, the COVID-19 crisis with its supply chain interruptions, the subsequent energy crisis with sharp price increases for energy carriers, and especially the Russian invasion of Ukraine have significantly altered the global trade context, putting the spotlight on Europe's supply vulnerabilities and the (lack of) internal renewable production capabilities given the net-zero climate targets for 2050. Hence, besides the post-COVID-19 recovery, resilience and strategic autonomy also came more into the policy foreground as necessary conditions to generate economic growth and jobs while decoupling the environment and climate impact.

The REPowerEU Plan was a direct response to the global energy market disruption in the wake of the Russian invasion of Ukraine. It focussed on energy saving, diversifying supplies and accelerating the deployment of renewable energy. With respect to wind energy, the REPowerEU especially indicated offshore wind as a significant future opportunity and emphasized that supply chains needed to be strengthened, e.g. using IPCEI's, or by accelerating permitting procedures[654]. The REPowerEU Plan is, in fact, the transition pathway for the renewable energy sector[655].

The REPowerEU Plan extended the set of proposals under the **Fit for 55 Package** which was launched a year earlier in July 2021.[656] The main focus of the Fit for 55 Package was attaining a net emissions reduction of at least 55% by 2030 compared to 1990 and being the first climate-neutral continent by 2050[657]. The underlying philosophy was "cementing the EU's global leadership by action and by example". However, the exogenous transition shocks described above challenged the feasibility of this view. The Commission's communication on the Fit for 55 Package explicitly mentions the link with SMEs, particularly in the field of innovation via the following instruments: (i) Horizon Europe: providing support for SMEs, start-ups, and spinout companies to develop and scale-up green innovations; (ii) IPCEIs: enhancing openness and facilitate participation; (iii) Support for investments in clean energy innovation projects and infrastructure from the Innovation Fund.

[653] The Energy Union was published on the 25th of February 2015 as one of the key priorities of the Juncker Commission (2014-2019). The Energy Union has five dimensions 1) energy security, 2) a fully integrated internal energy market, 3) energy efficiency, 4) decarbonising the EU economy with leadership in renewable energy and 5) research, innovation and competitiveness supporting clean energy technologies. More information can be found at this webpage: Energy union (europa.eu)

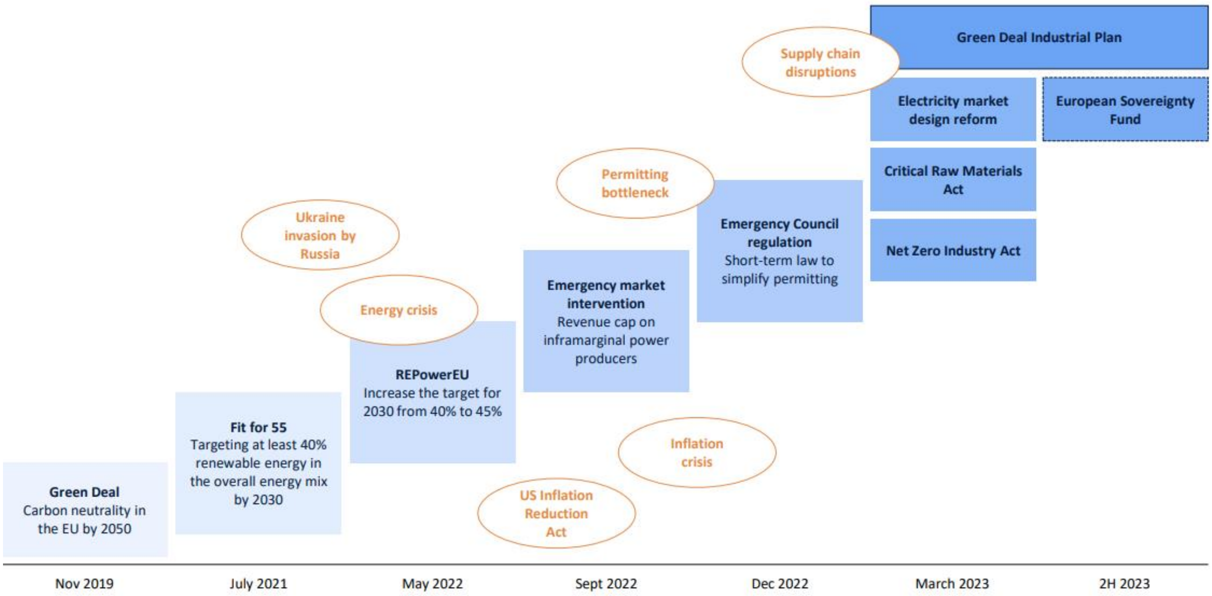
[654] European Commission (2022) p 6.

[655] For an overview of transition pathways we refer to EU Transition Pathways (europa.eu)

[656] The Fit for 55 Package is a set of inter-connected proposals combining policies focused on pricing (i.e. the European Emissions Trading Scheme, the New Carbon Border Adjustment Mechanism), specific targets (e.g. updated Renewable Energy Directive), standards and rules underpinned by support measures from the Social Climate Fund and the enhanced Modernisation Fund.

[657] European Commission (2021) Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, 'Fit for 55': delivering the EU's 2030 Climate Target on the way to climate neutrality, Brussels, 14.07.2021, COM(2021) 550 final, p. 1. Accessible from EUR-Lex - 52021DC0550 - EN - EUR-Lex (europa.eu)

Figure 60: Timeline of major EU renewable energy policy strategies, initiatives and legislation since December 2019



Source: RystadEnergy (2023)[658], p. 14

The R&D&I focus has been clearly articulated in the **European Strategic Energy Technology Plan (SET Plan)**. The SET Plan is a strategy that aims to accelerate the research, development and deployment of green technologies to enhance the transition towards a climate-neutral economy in a fast and cost-competitive manner[659]. The SET Plan was established in 2007. Since the creation of the Energy Union in 2015, it became an important instrument to promote research, innovation, and competitiveness, which is the Energy Union's fifth pillar. The SET Plan activities are grouped into 10 actions for R&D&I across all TRL levels. Particularly for the EU wind energy sector, the following actions are of interest: (i) Action 1, Integrating renewable technologies in energy systems; and Action 2, Reducing costs of technologies. These actions are implemented by 14 Implementation Working Groups (IWGs) each of which focuses on a particular technology. The IWGs are supported by European Technology and Innovation Platforms (ETIPs) and the European Energy Research Alliance (EERA). The ETIPs bring together Member States, industry, and researchers. The EERA brings together more than 250 research organisations from 30 countries involved in 18 joint programmes. The SET Plan helps promote cooperation between EU MS and companies by coordinating R&I activities in low-carbon technologies and aligning R&I programmes with its agenda. The revision of the SET Plan, adopted on 20 October 2023, harmonised the original SET Plan goals with the European Green Deal, the REPowerEU Plan and the Green Deal Industrial Plan, including the Net-Zero Industry Act[660]. The revised SET Plan extended its activities to include onshore wind energy as part of Priority 1, "Becoming world number one in renewables".

[658] RystadEnergy (2023) The State of the European Wind Energy Supply Chain. A "what-would-it-take" analysis of the European supply chain's ability to support ambitious capacity targets towards 2030. April 2023, 56 pp accessible from The State of the European Wind Energy Supply Chain | WindEurope

[659] See e.g. Strategic Energy Technology Plan (europa.eu)

[660] European Commission (2023) Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, on the revision of the Strategic Energy Technology (SET) Plan, Brussels, 20.10.2023 COM(2023) 634 final, accessible from eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52023DC0634

The National Energy & Climate Plans (NECPs) were introduced as part of the Clean Energy for All Europeans package which was adopted in 2019. All Member Sstates report in their respective NECPs how they plan to address the five dimensions of the Energy Union: decarbonisation, energy efficiency, energy security, the internal energy market and research, innovation and competitiveness. Every two years, the Member States submit a progress report to the Commission. Originally, the time focus was 2030. From 2020 onwards, the long-term strategies for 2050 must be included as well. As of September 2023, 15 of the 27 NECPs were published. ETIP Wind analysed five country reports: Denmark, Netherlands, Italy, Portugal and Spain. Among others, ETIP Wind concluded that R&I actions supporting manufacturing capacity were absent or lacking in detail for all five countries[661].

In February 2023, the Green Deal Industrial Plan was presented to enhance the competitiveness of the EU net-zero industry and to accelerate the transition to climate neutrality by 2050. The plan focused on four pillars, while three initiatives were taken to improve the regulatory environment, including the Net-Zero Industry Act, which aimed to simplify the regulatory framework and improve the investment context for the EU's net-zero energy technologies manufacturing capacities. [662] **The Net-Zero Industry Act refers explicitly to SMEs in the context of innovation** (Chapter VI, articles 26 and 27), asking MS to provide SMEs priority access to the Innovative Net-zero regulatory sandboxes. Article 27 also refers to Member States for awareness-raising activities about these regulatory sandboxes and for providing guidance and administrative support to SMEs for participation[663].

In October 2023, the Commission presented two initiatives, collectively referred to as the EU Wind Power Package, to accelerate wind energy and deployment in the EU[664]. The first initiative is the European Wind Power Action Plan. The second is the European Wind Charter. The European Wind Power Action Plan[665] defines 15 actions grouped in six pillars [666]to strengthen Europe's wind energy industry.

In December 2023, Member States together with leading industry representatives, signed the **European Wind Charter,** which included a set of voluntary commitments to support the development of the EU's wind sector. On the same occasion, 21 Member States submitted concrete pledges for wind energy deployment volumes for the period 2024-2026, both for onshore and offshore wind. The hopes are mainly focused on the deployment of offshore wind energy, as specified in the Commission's communication on "Delivering on the EU offshore renewable energy ambitions [667].

Quite a number of policies may indirectly impact the competitiveness of the SMEs in the EU wind energy sector. For example, the EU Supply Chain Directive, proposed by the European Commission on 23 February 2022 as the Corporate Sustainability Due Diligence

---

[661] ETIPWind (2023) National Energy & Climate Plans – The rôle of Research & Innovation in delivering a competitive wind energy supply chain « made in Europe » accesible from [231008 Factsheet NECPs (etipwind.eu)]

[662] The other two initiatives are: (i) The Critical Raw Materials Act, improving access to critical raw materials such as rare earths; (ii) The Reform of the electricity market design, lowering the costs of renewables for consumers.

[663] European Commission (2023) Proposal for a regulation of the European Parliament and of the Council on establishing a framework of measures for strengthening Europe's net-zero technology products manufacturing ecosystem (Net Zero Industry Act), Brussels, 16.03.2023 COM(2023) 161 final, p 54.

[664] See e.g. [EU wind energy - European Commission (europa.eu)]

[665] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS European Wind Power Action Plan; COM/2023/669 final, accessible from [EUR-Lex - 52023DC0669 - EN - EUR-Lex (europa.eu)]

[666] The six pillars are: (i) Acceleration of deployment via faster permitting; (ii) Improved auction design; (iii) Improved access to finance, de-risking tools, and guarantees and flexibility provided under State Aid rules for the EU wind value chain; (iv) A fair and competitive international market environment; (v) Skills; (vi) Industry engagement and Member State commitments via the EU Wind Charter.

[667] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Delivering on the EU offshore renewable energy ambitions; COM/2023/668 final, accessible from [EUR-Lex - 52023DC0668 - EN - EUR-Lex (europa.eu)]

Directive (CSDD), obliges large companies to ensure that not only their own activities but also the activities of their upstream suppliers comply with human rights and environmental sustainability criteria. Although the CSDD only targets large companies that have the necessary capacities to implement the due diligence and carry the compliance requirements[668], business associations, such as the VDMA and ZVEI in Germany, point to the danger that large companies will impose similar obligations to the supplier SMEs to minimize liability risk, and hence create additional administrative burdens for SMEs even to the ones contributing to the very goal for which the CSDD was designed, namely mitigating adverse environmental and climate impacts.

10.1.3 Recommendations for future policy actions

From the previous section, it can be concluded that gradually, the EU is building its (renewable) energy market framework through various initiatives, strategies, and laws. Due attention is given to competitiveness and innovation of clean energy solutions. Although the SET Plan is the EU's overarching strategy to foster the development and deployment of carbon-neutral technologies, the recent evaluation of five National Energy and Climate Plans concluded that R&D actions to support the MS manufacturing capacity were absent. Moreover, apart from a few exceptions, explicit references to SMEs are virtually absent as well. This suggests that the underlying hypothesis is that ensuring adequate framework conditions for fostering wind sector development will automatically benefit the SMEs in the sector. As depicted above, interviews and the analysis of the main renewable energy policies suggest that this hypothesis does not always have to be taken for granted, and specific measures for SMEs are needed.

Scaling-up SMEs activities via increases for innovative solutions, skills, as well as finance and investments. The Fit for 55 Package explicitly referred to Horizon Europe, IPCEIs and the Innovation Fund. The Net-Zero Industry Act explicitly addresses Net-zero regulatory sandboxes. Moreover, intermediary organisations within the Member States are important actors for the operationalisation of these instruments and for the proliferation of best practices, as well as for co-elaborating tailor-made solutions given the industrial, skills, technology, and material specialisation patterns of the Member States. A systematic reporting in the NECPs of the Member States' initiatives focused on SMEs in the wind energy sector would provide a better overview for the EU as a whole. This does not necessarily guarantee the effective execution of SME-oriented actions by the Member States. Yet, it at least provides better monitoring and a basis for exchanging best practices connected with, for instance, regional or national smart specialisation strategies. On top of that, due attention should be paid to the lagging SMEs in terms of awareness raising, promoting innovation, easing access to finance, fostering skills development, and support for entering new market niches intra and extra EU27. Finally, despite the sheer size of EU funding to support net-zero industries, the effect in terms of number of SMEs reached might be relatively limited. Financial leverage for scale-ups may be increased by combining EU funding and MS funding schemes tailored to the SME business segment of the wind energy sector (multiplier effect). Cascade funding schemes are instrumental in this respect.

Helping SMEs to be conducive in closing the loop for wind turbine manufacturing by transferring knowledge and finance (see above), **cutting red tape and administrative burden, and facilitating access to new markets** within and outside the EU. While the current

[668] We refer to the answer given by Commissioner Reynders on behalf of the Commission to a Parliamentary question (E-000281/2024 (ASW)) related to the concerns of eight German business associations requesting the scrapping of the directive Parliamentary question | Answer for question E-000281/24 | E-000281/2024(ASW) | European Parliament (europa.eu) and Parliamentary question | EU supply chain directive | E-000281/2024 | European Parliament (europa.eu). The call of the eight German business associations can be found here: Microsoft Word - 2024-01-18_Urgent call Stop the EU Corporate Sustainability Due Diligence Directive (zvei.org)

policy focuses on installing additional onshore and especially offshore capacity, decommissioning, repowering, and recycling are gradually gaining importance due to the end-of-life phases of the first wind turbines installed. These market segments will become more important in the future. They provide new business opportunities for both established SMEs and start-ups in the wind energy sector as for those outside. SMEs can be conducive to closing the loop for wind turbine manufacturing, although significant technical challenges still remain, e.g., in recycling blades, including administrative access to existing funding opportunities, e.g., to Horizon Europe.

Developing an EU-level strategy to support energy communities across various policy areas could further enhance their role in the energy market. Cooperatives have been a relative success story in the development of wind energy and other sources of renewable energy. Energy cooperatives, or energy coops, are formed by citizens to collectively address renewable energy, energy efficiency, and related activities. These cooperatives vary widely in size, governance, structure, and activities. Some are small, with fewer members, and focus on small-scale projects like solar panels, while others, like Ecopower in Belgium, serve tens of thousands of homes with renewable energy. Projects range from wind turbines to solar panels, often combining various renewable sources.[669] As the experience from Denmark, among other countries, shows, the model often works well and ensures a buy-in from local communities and energy consumers. MS and regions would be advised to encourage the establishment and expansion of such cooperatives. To accelerate the transition to renewable energy, the EU must also ensure full transposition and implementation of rules set by the Clean Energy for all Europeans Package, creating regulatory frameworks that support energy communities. Developing an EU-level strategy to support energy communities across various policy areas could further enhance their role in the energy market. While some MS have made progress in transposing these provisions into national legislation, many have still to create enabling frameworks for energy communities to participate in the market without discrimination.

[669] REScoop.eu is an EU-wide project to support new initiatives by including them in our well-experienced network offering them tools, and sharing good practices.

10.2 Solar energy

Highlights:

- Solar PV energy production in the EU has grown significantly, with ambitious targets set for 2030 to increase capacity, despite strongly declining EU manufacturing capacities in recent decades and years, reaching a global share of 1% of solar c-PV module production.
- The EU faces challenges in competing with low-cost Asian manufacturers, in particular from China, leading to market consolidation and declining market share. The EU's dependence on Chinese manufacturers poses risks, including supply chain vulnerabilities and technological dominance.
- Despite challenges, the solar industry in the EU provides significant job opportunities, with around 800,000 people employed in installation and maintenance, among other economic activities.
- SMEs play a limited role in the manufacturing chain, primarily in niche markets. Agri-photovoltaics, road-integrated PV, floating PV, vehicle-integrated PV are promising routes, among others.
- Various policy initiatives have been taken, virtually all focussed on the sector as a whole and without SME-specific measures for solar PV manufacturers. The Solar Energy Strategy is the key policy instrument for solar PV. It contains the Solar Rooftop Initiative, a revision of the Renewable Energy Directive to make obtaining permissions simpler and faster, the skills partnership and the EU Solar PV Industry Alliance covering triple helix stakeholders.
- It is recommended that future policy actions focus on:
    - helping to reach startups and SMEs their minimum production scale, through for instance financial support via COSME or via the SME specific instruments used in the Member States
    - Disseminating information and co-training public authorities to deal with the complexities and technicalities of Green Public Procurement for effectively using it for strategic purchases to the benefit of SME and other solar PV manufacturers in Europe.
    - Sustaining the innovation absorption capacity of SMEs in the EU solar PV value chain. The role of intermediaries such as university tech transfer offices, SME supporting government agencies and specialised cluster organisations is important.
    - Helping to create a global level playing field for instance via the Trade and Technology Council (TTC). Within that context the following initiatives are important for the EU solar PV sector (i) Transatlantic Initiative on Sustainable Trade; (ii) Transatlantic Green Market Place; (iii) EU-US Clean Energy Incentives Dialogue; (iv) Cooperation in strategic supply chains.

10.2.1 Overview of the value chain, positioning of SMEs and strategic vulnerabilities

10.2.1.1 The solar PV value chain

Figure 61 presents a schematic overview of the solar PV value chain based on silicon wafer technology from raw materials to modules and back to decommissioning with the recycling of materials. The production phases are discussed below:[670]

Polysilicon production, which serves as the raw material for solar cells. It is produced by reducing sand (silica) to raw silicon and then purifying it. This step is crucial because high-quality polysilicon ensures efficient solar cell performance.

Ingot manufacturing follows the production of purified polysilicon. Ingots are large, cylindrical blocks of crystalline silicon. They serve as the starting point for **wafer production,** where ingots are sliced into thin wafers using a process called wafer cutting. Wafers are typically around 180-200 micrometers thick and serve as the base material for solar cells.

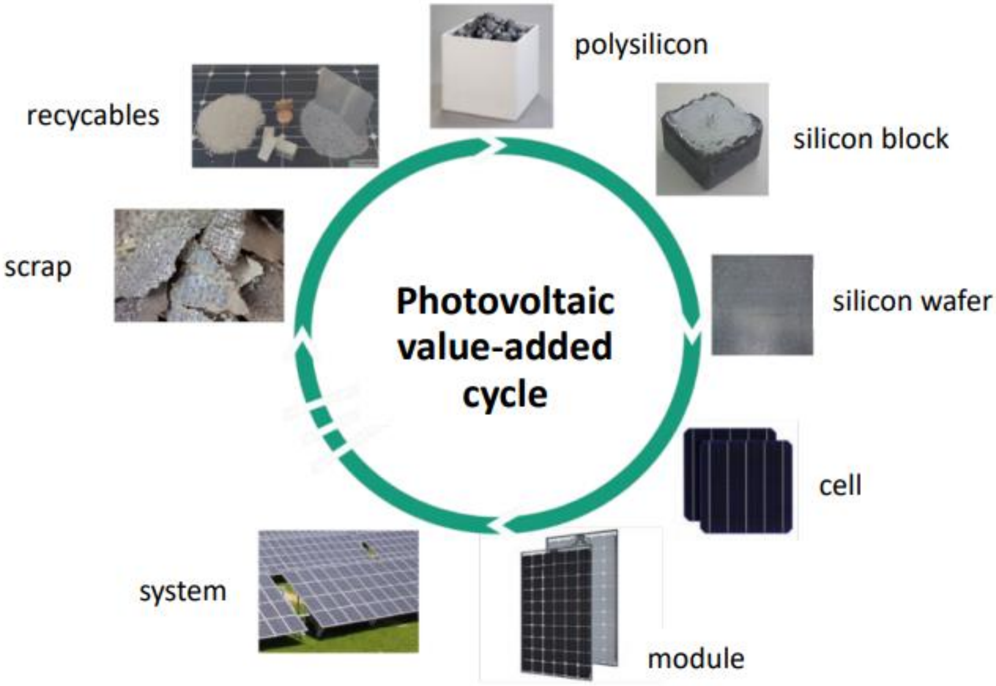
Solar cell fabrication undergoes several steps to become functional solar cells: (i) doping, the wafers are doped with specific materials (such as phosphorus or boron) to create the necessary electrical properties; (ii) cleaning to remove impurities; (iii) coating, i.e., a layer of anti-reflective coating is applied to enhance light absorption, and (iv) cell assembly, where metal contacts are added to create an electrical circuit within the cell.

Module assembly (panel manufacturing) consists of multiple interconnected solar cells. They are encapsulated in protective materials (such as glass and polymer) to withstand environmental conditions, and electrical connections are made to ensure efficient power output

The final phase includes services and deployment, and, specifically distribution, installations, and operation and maintenance to ensure optimal performance and longevity.

[670] Beyond the OEM solar PV manufacturing chain, say Tier 1, a substantial number of suppliers are involved and this in each of the stages indicated, for instance: (i) material production, notably solar silicon, metal pastes, connector wires, plastic foils, solar glass, glass coating, (ii) Intermediate and final products such as module frames, cables, inverters, mounting structures, tracker systems; (iii) the mechanical engineering for the cell and module production; (iv) power plant operation and maintenance; (v) decommissioning, material recycling.

Figure 61. The solar photovoltaics value chain



Source: Wirth, H. (2024) Recent Facts about Photovoltaic in Germany, Fraunhofer ISE, version 16.01.2024, p. 21, accessible from Recent Facts about Photovoltaics in Germany - Fraunhofer ISE

10.2.1.2 The solar PV value chain in the EU: high demand but vanishing EU production

Solar photovoltaic energy production, together with solar thermal, is one of the eight strategic technologies in the Net-Zero Industry Act. Although wind energy and hydropower generate together 67.4% of total renewable electricity production in the EU, based on the latest Eurostat data for 2022, **solar power is growing fast**. In 2008, the volume produced was 7.4 TWh. By 2022, this was 210.3 TWh, which implies a CAGR of 27%. In 2022, solar power represented 18.2% of the renewable energy generated in the EU[671] (Figure 62).

The expectations about solar PV in terms of its contribution to renewable energy generation, with the ultimate purpose of attaining a net zero EU economy by 2050, are high. According to the latest report from the Commission on the progress in the competitiveness of clean energy, solar PV plays a crucial role in all scenarios to reach a climate neutral energy system.[672]

The EU Solar Energy Strategy aims to reach a mere 600 GWac (or 720 GWp)[673] installed capacity by 2030, which implies an almost threefold increase in Solar PV capacity compared

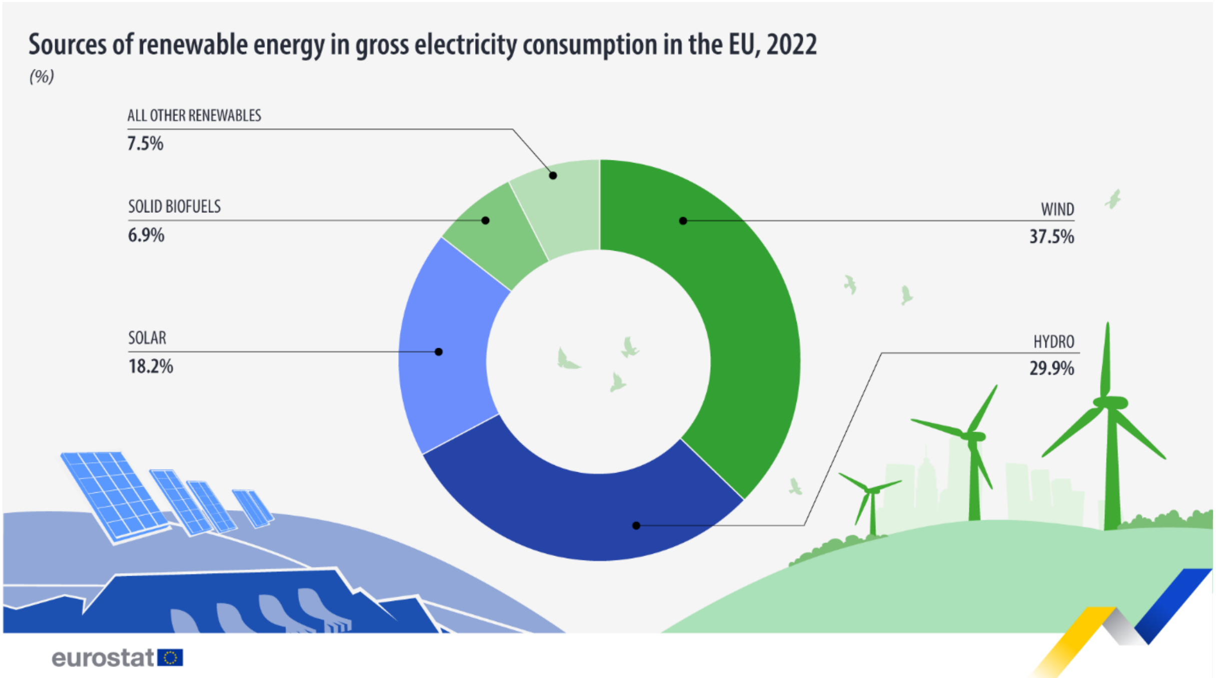
[671] Based on Eurostat (2024) Renewable energy statistics - Statistics Explained (europa.eu)

[672] European Commission (2023) Report from the Commission to the European Parliament and the Council – Progress on competitiveness of clean energy technologies, Brussels, 24-10-2023, COM(2023) 652 final, p 20 available on EUR-Lex - 52023DC0652 - EN - EUR-Lex (europa.eu)

[673] GWp (gigawatt peak) refers to the direct current capacity of solar PV modules at maximum output and standard test conditions. GWac refers to the maximum electricity output considering the conversion from direct current to alternating current. For more insight in the intricacies of reporting capacity numbers we refer to Chatzipanagi, A., Jaeger-Waldau, A., Cleret De Langavant, C., Gea Bermudez, J., Letout, S., Mountraki, A., Schmitz, A., Georgakaki, A., Ince, E., Kuokkanen, A. and Shtjefni, D., Clean Energy Technology Observatory: Photovoltaics in the European Union - 2023 Status Report on Technology Development, Trends, Value Chains and Markets, Publications Office of the European Union, Luxembourg, 2023, doi:10.2760/732675, JRC135034. Photovoltaics in the European Union (europa.eu) p.16

to 2022. Based on the latest Eurostat data, in 2022, the EU-27 hosted about 203 GW solar photovoltaic production capacity (Figure 63). To reach the 2030 target for solar photovoltaics, about 49.6 GW additional capacity has to be installed each year[674]. From a historical point of view, the Eurostat data show that the largest addition to solar PV capacity in the EU27 was realised in 2022 with more than 47 GW. At the writing of this report, no official numbers for the year 2023 are available. Yet, in its latest European Market Outlook SolarPower Europe (2023) estimates that in 2023 a new record of 56 GW was installed[675]. This suggests that the 2030 target seems feasible. Yet, the association adds that it expects a slowdown in the growth path for 2024.

Figure 62. Sources of renewable energy in gross electricity consumption in the EU-27, year 2022

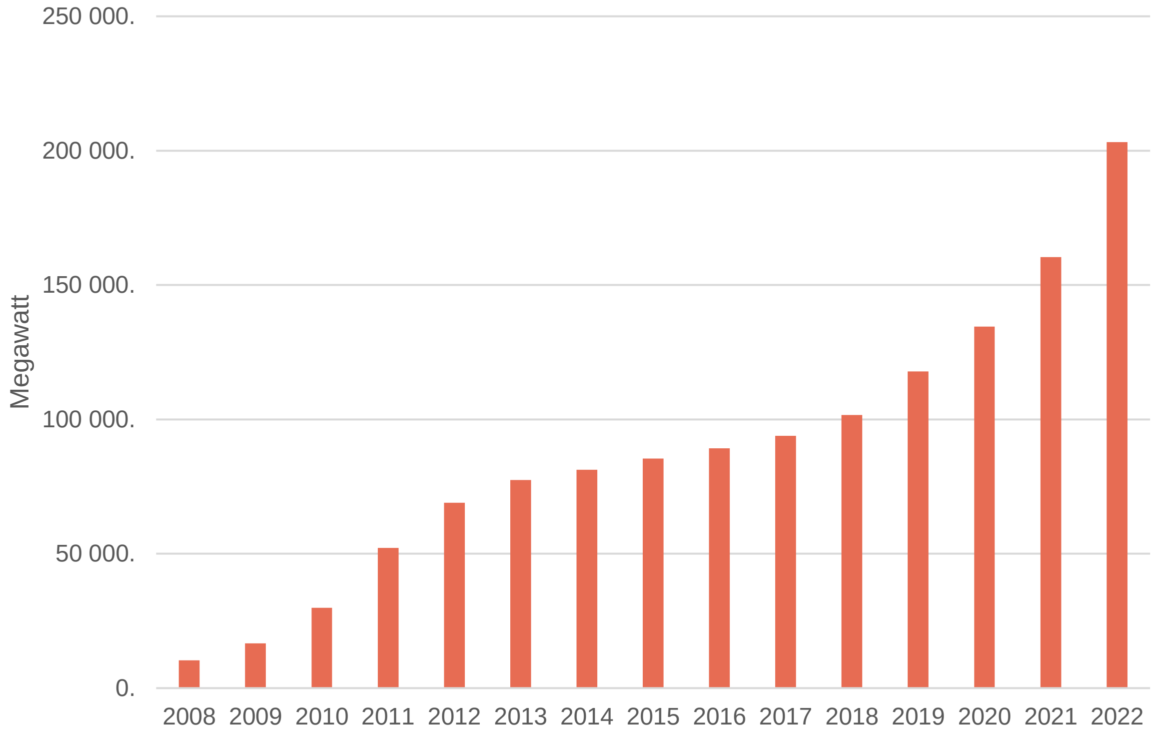


Source: Eurostat (2024) Electricity from renewable sources up to 41% in 2022, accessed 26-02-2024 from [Electricity from renewable sources up to 41% in 2022 - Eurostat (europa.eu)]

[674] Estimated as a linear intrapolation between the 2030 target and the Eurostat data for 2022.

[675] New report: EU solar reaches record heights of 56 GW in 2023 but warns of clouds on the horizon - SolarPower Europe

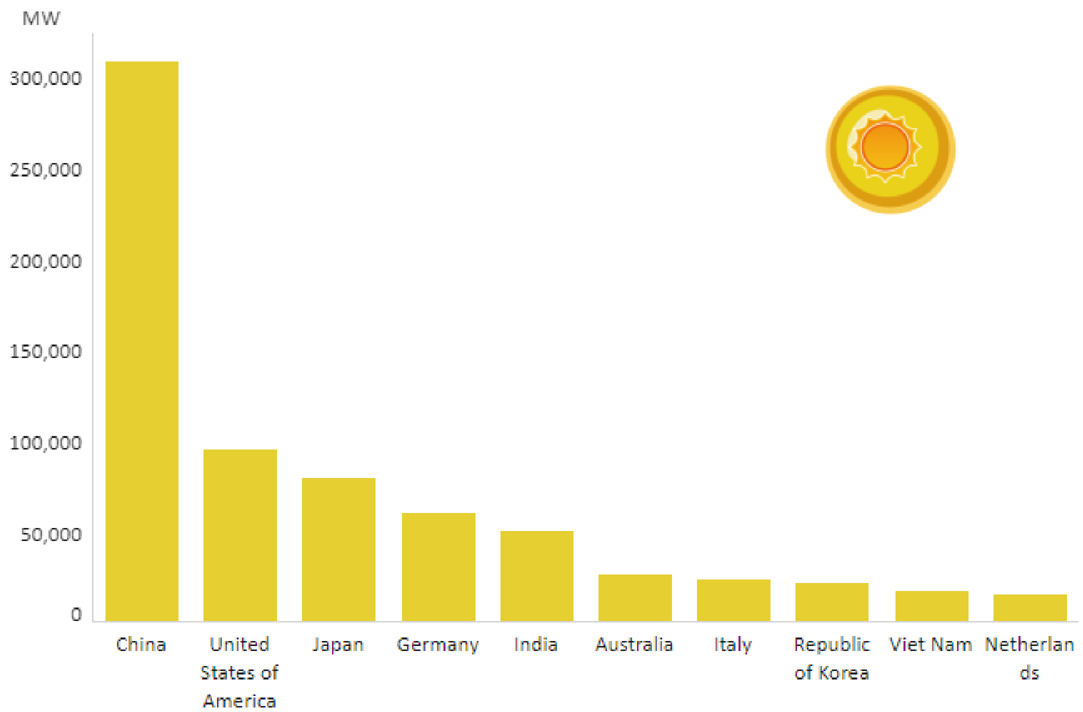
Figure 63. Evolution of electricity production capacities for solar photovoltaic energy in the EU-27 since 2008, net maximum electrical capacities



Source: Eurostat (2024) Electricity production capacities for renewables and wastes [nrg_inf_epcrw] last accessed 01-04-2024

To put the EU figures in the global context, it is worth looking at the top 10 countries in terms of electricity capacity for solar photovoltaic. Figure 64 indicates that **the capacity in China is one and a half times that of the EU27 and threefold that of the United States**.

Figure 64. Electricity capacity for the top 10 countries for solar photovoltaic in 2021



Source: IRENA (2024) Country Rankings (irena.org) accessed 29-03-2024

While the deployment of solar panels is on a sharp upward trajectory in the EU, the manufacturing of solar panels is in a long-term decline. Already a decade ago, it was clear that EU manufacturing was rapidly losing market share, signalled by a strong market consolidation and bankruptcies of EU firms. This was mainly due to the strong competition from low-cost Asian manufacturing companies. The IEA (2022)[676] indicated, for instance, that the profitability of German producers took a sharp hit even before due to price competition from Chinese rivals. This is clearly shown by the recent Photovoltaics Report from Fraunhofer ISE, as illustrated in Figure 63, on the European scale and in a larger time window. Before 2010, the EU module producers held between 20% and 40% of global market shares. Since 2010, manufacturing capacities in Asia have increased substantially, at the expense of other producers, including those in the EU. According to Statista's latest estimates, the EU share of solar PV module manufacturers in 2021 was 3% in terms of capacity[677]. For the production of crystalline silicon (c-SI) PV modules, European manufacturers accounted for 1% of global supply[678].

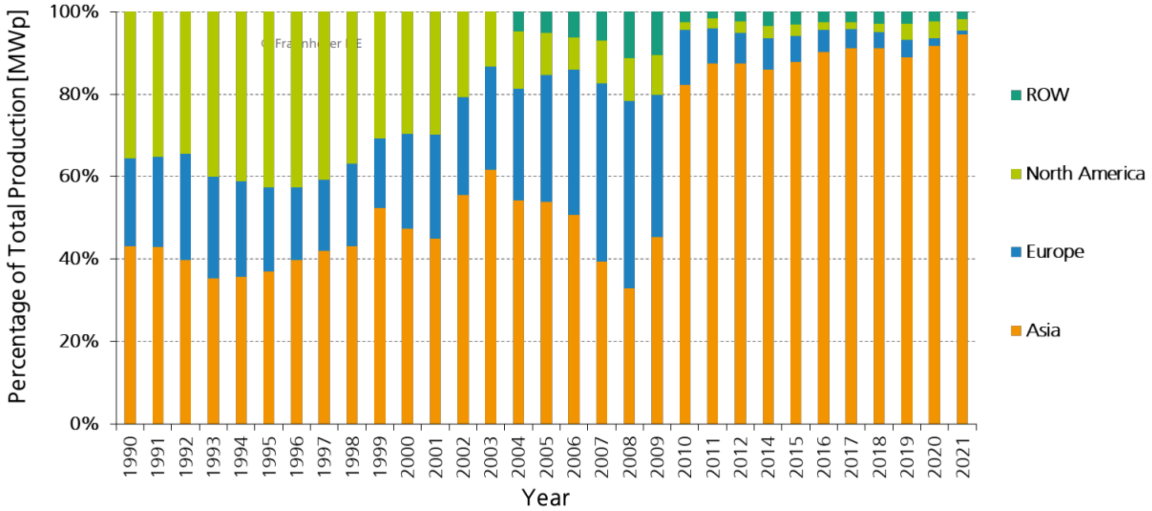
The future market outlook looks bleak, given the massive imports of solar PV panels from China and the oversupply it generates in the EU market. Industry experts estimate that module prices have plummeted to one third of the previous price and that in 2023 there was a surplus stock in EU harbours and warehouses of about 85GW, corresponding to more than 150 million PV modules and more than a year's supply. Consequently, manufacturers were obliged to reduce production or even temporarily stop production, as NorSun did for its ingot and wafer production. Other producers of ingots and wafers Norwegian Crystals and REC Solar Norway closed entirely. A similar experience can be found PV module segment. In 2023, Exasun (Netherlands) and Energetic (Austria) went bankrupt, which meant a combined loss of 180MW PV module manufacturing capacity. Sector representatives estimate that, together with other examples, more than half of Europe's solar PV module manufacturing capacity has been affected.

[676] IEA (2022) Special Report on Solar PV Global Supply Chains (windows.net) p 109

[677] See Europe: solar PV manufacturing capacity & production shares | Statista

[678] Fraunhofer ISE (2023) Photovoltaics Report, 21-02-2023, p. 5. accessible from https://www.ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/Photovoltaics-Report.pdf

Figure 65. PV Module production by global region 1990-2021 expressed as percentage of the total MWp produced.



Source: Fraunhofer ISE (2023) Photovoltaics Report, 21-2-2023, p 12.; accessible from https://www.ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/Photovoltaics-Report.pdf

10.2.1.3 The role of SMEs in the EU production chain

SolarPower Europe provides a geographic snapshot of companies and organisations that are active in the solar PV value chain. Their dataset contains 166 companies that cover all stages of solar PV manufacturing, as well as research centres and equipment manufacturers for producing the various components. Germany hosts a strong concentration of solar PV manufacturing facilities and, at the same time, has 36% of the EU27 cumulative installed capacity[679]. The scientific literature[680] points out the important role of supportive policies in stimulating the energy transition. In this respect, the feed-in tariffs in the various Member States have been instrumental. This suggests that closeness to the market has been a key driver for location. Yet the authors equally indicate that these policies attract foreign competitors as well. Although this may be perceived as a negative externality from a local firm perspective, it helps create an ecosystem or cluster around solar PV. Firm idiosyncrasies play a role as well, specifically the experience with the industrial policy measures of the Member States. Interestingly, the authors also conclude that sudden changes in industrial policies not only raise the aversiveness of potential investors but also incentivise them to favour or rank other Member States relatively more. Hence, the relevance of an overarching EU renewable energy policy.

[679] Fraunhofer (2023) Photovoltaics Report, 21 February 2023, p. 4. Data are for end of 2021.

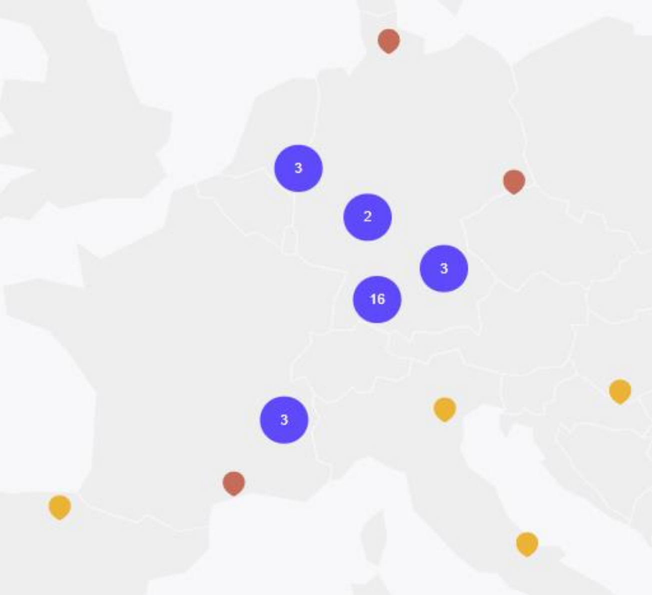
[680] Georgallis, P., Albino-Pimentel, J., Kondratenko, N., (2021) Jurisdiction shopping and foreign location choice: The role of market and nonmarket experience in the European solar energy industry, in Journal of International Business Studies vol. 52, pp 853-877, available at Jurisdiction shopping and foreign location choice: The role of market and nonmarket experience in the European solar energy industry | Journal of International Business Studies (springer.com)

Figure 66. Geographic distribution of solar PV manufacturers in the EU (108 companies) – data SolarPower Europe

Source: SolarPower Europe (2024) EU Solar Manufacturing Map, [EU Solar Manufacturing Map - SolarPower Europe] accessed 30-03-2024
Note: the value chain components covered are the manufacturing of cells, wafers, modules, module components, inverters, trackers, polysilicon, ingots and smart fab solutions.

Figure 67 provides an overview of the geographic distribution of equipment manufacturers in Europe, based on the data of SolarPower Europe. Most of the manufacturing plants are located in Germany.

Figure 67. Geographic distribution of equipment manufacturers for solar PV in the EU (34 companies)



Source: SolarPower Europe (2024) EU Solar Manufacturing Map, [EU Solar Manufacturing Map - SolarPower Europe] accessed 30-03-2024

Note: the value chain components covered are cell production equipment, module production equipment, wafer production equipment, ingots production equipment and polysilicon production equipment.

There is little publicly available information on the role of SMEs within the production ecosystem, with the literature focused on SMEs as end users of solar energy. Given the nature of solar PV manufacturing with strong economies of scale, the role of SMEs is most likely limited, though. An exception is pure solar module manufacturing. Because of the comparatively lower investment costs involved in pure solar module manufacturing compared to other stages of the solar module manufacturing process, this segment has experienced the most significant level of activity. However, it is predominantly propelled by numerous small and local companies, each operating within capacities in the sub-GW range. By 2023, at least 57 module manufacturers had established factories within the European Union.[681]

The main EU manufacturing companies in the EU solar PV value chain are large. Well-known examples include Wacker Chemie from Germany, which has a production capacity of 20 GW of solar polysilicon and is the fourth largest producer worldwide. Others include Meyer Burger (Germany), 3Sun (Italy), MCPV (Netherlands). However, a few small-scale companies still exist, mainly in module manufacturing. Based on interviews, we assess that the surviving small-scale module producers focus on particular niche markets, for instance, by integrating module production with client specific installation and maintenance requirements. As such, the business models come close to so-called Product Service Systems (PSS) where the clients ultimately pay for the energy produced but where the capital expenditure (capex) and operational expenditure (opex) largely remain with the module manufacturers and installers.[682]

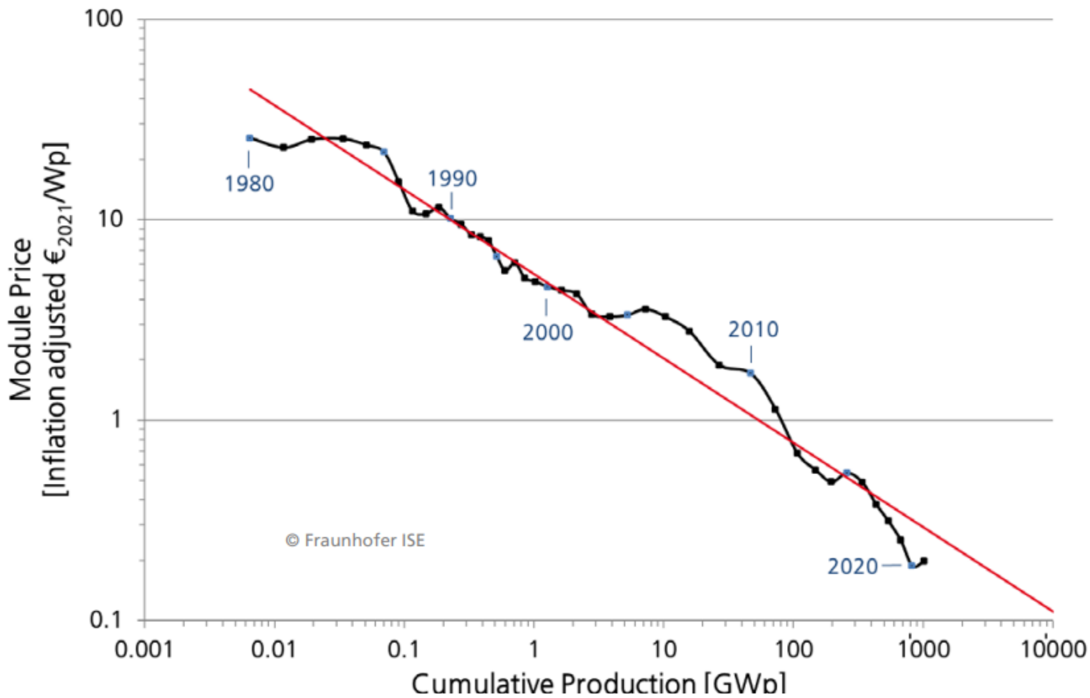
[681] https://www.solarpowereurope.org/insights/outlooks/eu-market-outlook-for-solar-power-2023-2027

[682] See e.g. Schmidt-Costa, J., Uriona-Maldonado, M., Possamai, O. (2019) Product-service systems in solar PV deployment programs: What can we learn for the California Solar Initiative? In Resources, Conservation and Recycling, vol. 140, January 2019, pp. 145-157, accessible from [Product-service systems in solar PV deployment programs: What can we learn from the California Solar Initiative? - ScienceDirect]. Interestingly the authors conclude that the results of their study suggests that the PSS approach led to a significant increase in the installed solar PV capacity and led to positive long-term network externalities.

10.2.1.4 Strategic vulnerabilities

In contrast to the wind energy value chain, solar PV is a relatively standardised technology with solar PV modules as its end-product, which can be applied in various settings and applications. Hence, scale economies are important and drive unit production costs. Figure 68 shows that in the last 41 years, each time the cumulative PV-module production doubled, the price declined by approximately 25%. Hence, this provides an underlying cost advantage for large-scale plants and production facilities. The standardised nature of the technology, as well as economies of scale, enabled Chinese manufacturers to increase its market share globally.

Figure 68: The price learning curve in solar PV production over time



Source: Fraunhofer ISE (2023) Photovoltaics Report, Freiburg, 21 February 2023, p.48

Given the importance of solar PV for attaining the net-zero ambitions by 2050 and the interim targets of 600 GWac in the context of the EU Solar Energy Strategy, **the dependence on China foreign manufacturers is worrisome**. A recent report indicates that the supply of solar components in the EU is not ensured due to the critical monopoly built up by the solar PV industry in China[683]. In 2022, China's market share for the production of polysilicon and silicon wafers was about 85%. It was close to 60% for solar cells, and for modules, it reached 70%. The author highlights that the production of certain feedstocks has stopped entirely in the EU.

The IEA (2022) concluded that "China significantly dominates every single solar PV supply chain segment" [684]. Even if module production is more geographically diversified, producers still depend on Asia for all key inputs. The report also indicates that China became a leading supplier of equipment for solar PV manufacturers. So, even when solar PV manufacturing in the EU increases from its current low base, chances are high that the equipment manufacturers of China or other Asian countries will also benefit.

[683] Wirth, H. (2024) Recent Facts about Photovoltaic in Germany, Fraunhofer ISE, version 16.01.2024, p. 21, accessible from Recent Facts about Photovoltaics in Germany - Fraunhofer ISE

[684] IEA (2022) Special Report on Solar PV Global Supply Chains (windows.net) p.17

It has been shown that in the ingots and wafers segment, **the EU has witnessed a substantial loss in research and innovation as well as in the capacity to manufacture specialised tools**[685]. This is largely a consequence of the declining share of PV manufacturing globally, as discussed above. As is the case for many industries, the valorisation of R&D is closely linked to the presence of relevant industries. It is indicative that the annual R&D spending of the largest PV wafer, cell and module producers in China, among others LONGi, Trina Solar, Jinko Solar, Tongwei, JA Solar Holdings, Yingli Solar, Risen Energy, Astroenergy, equals or even surmounts the total R&I spending on solar PV for the 2014-2020 period under the EU Horizon 2020 programme. Given the smaller size of the EU solar PV manufacturers, the R&D budgets are smaller as well, which in turn leads to comparatively less adoption of new technologies. Hence, rebuilding the EU solar PV value chain is an uphill battle.

Scale not only co-determines R&D funding, but it also influences profitability. Vertically integrated solar industry manufacturing companies have outpaced the so-called pure-play companies that are active in only one specific segment of the solar PV value chain. The main reason is that integrated companies can compensate for the lower financial performance in one segment by better performance in another. Medium-sized integrated companies in solar PV in China receive stable revenues through long-term government contracts. Evidently other factors than scale determine the competitiveness of solar PV manufacturers. Materials and energy are key cost components in the production process, as shown in Figure 69.[686]

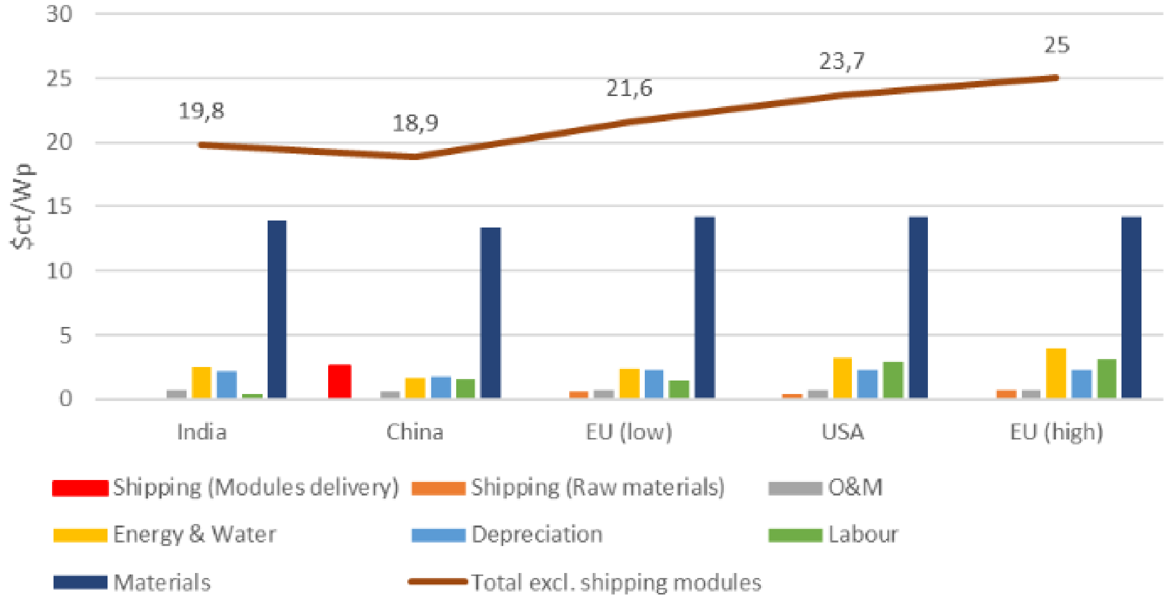
Energy and labour costs explain the major differences in solar PV manufacturing costs across regions. Even including the shipping costs for module delivery, the competitive disadvantage of the EU solar PV manufacturers can be substantial, as the region faces substantially higher energy and labour costs. The above-mentioned cost differences imply an additional cost spread between EUR 20 and 350 for a 10kW domestic installation. At the utility scale, with e.g. a 300 MW project, the additional investment cost for sourcing EU-made solar panels may be around EUR 10.5 million.[687]

[685] ETIP Photovoltaics (2023) PV Manufacturing in Europe: understanding the value chain for a successful industrial policy - ETIP PV Industry Working Group White Paper, May 2023, p. 16, accessible from https://etip-pv.eu/publications/etip-pv-publications/download/pv-industry-white-paper-6

[686] *Idem*.

[687] *Idem*.

Figure 69: Major production cost components for solar PV modules deployed in Europe, per region of origin



Source: Own chart on the basis of data in Figure 1 in ETIP Photovoltaics (2023) PV Manufacturing in Europe: understanding the value chain for a successful industrial policy - ETIP PV Industry Working Group White Paper, May 2023, p. 7, accessible from https://etip-pv.eu/publications/etip-pv-publications/download/pv-industry-white-paper-6.

Notes: Total costs excluding shipping for modules delivery from China to Europe/U.S.. The EU (low) scenario implies production in Eastern Member States with wage and electricity costs that are about half of the EU (high) scenario (old Member States), lower construction costs and lower costs for land.

Given the dominant position of the Chinese solar PV manufacturing sector, **the vulnerabilities of the EU in the solar PV manufacturing value chain are manifold**:

- The ability and power to **control global industry standards**. A report analysing the ingot-wafer segment of the solar PV in depth indicates that this is a real risk and points to the importance of its own EU internal market standards[688].
- Licenses and **export restrictions**. The previous study reports that experts in the EU solar PV manufacturing industry have divergent perceptions. One group of experts perceives export restrictions as a serious threat in the sense that the EU depends for specific materials, components and (parts of) machinery from Chinese manufacturers. The short-term consequences would be substantial, leading to the need to develop new business models to keep businesses afloat. On the other side of the spectrum are the experts who believe that export restrictions would benefit the European solar industry, yet only under conditions that the EU can produce the equipment at a competitive price.
- Access and **monopolisation of equipment**. Ingot and wafer manufacturing is the most vulnerable segment in the solar PV value chain in terms of the cost of re-shoring. One of the key components of the ingot-producing process is **Cz-pullers**. It is also the most expensive part of equipment in the ingot-wafer segment at almost half of production equipment investment costs. It has been claimed that setting up an ingot production

[688] Ortega Alvarado, O., Gervais, E., Nold, S., Lindahl, J. (2024) The current state of the EU photovoltaic industry. An in-depth look at the ingot-wafer supply chain. Final report summarizing the findings of interviews conducted for the supply chain gap study. Fraunhofer ISE and ESMC, January 2024, p. 15,

plant without relying on Chinese suppliers for Cz pullers is practically impossible.[689] There are only a few Cz puller equipment manufacturers outside China, and one of them Linton Crystal Technologies, although operating in the United States is Chinese-owned. Another example of equipment that is not produced in Europe is the production of **diamond wire saws** for wafer cutting.

- **Monopolisation of materials**. For instance, **quartz crucibles**, which is critical to produce ingots, are currently mainly sourced from China, although pilot projects from European manufacturers have been reported (Saint-Gobain, Sibelco, The Quartz Corp).
- **Supply risks and environmental, social and governance (ESG) issues.** Some experts[690] point to the supply and ESG risks that are connected with highly concentrated supply chains. The authors take the example of silver for photovoltaics production which goes through various stages from mining, refining, powder fabrication, paste fabrication, cell manufacturing to module manufacturing. Mining and refining are mostly concentrated in Mexico and China. Paste fabrication and cell and module manufacturing are concentrated in China. The authors concluded that virtually all silver used in PV is associated with very high ESG risks upstream. ESG risks analysed included Voice and Accountability, Water Resources, Biodiversity and Habitat, Occupational Toxins and Hazards, Social Benefits, Excessive Working Time and Child Labour.
- **Technological lead position for industrial-scale deployment**. Although the EU hosts valuable technological know-how, the operationalisation of industrial production processes is lacking. For example, the design of the hotzones in the Cz-pullers is a well-guarded factory secret that cannot be easily copy pasted into other production settings[691].
- **Oversupply and dumping**. The IEA 2022 refers to the monopoly position of the often integrated solar PV manufacturers in China in combination with its industrial policy to focus on solar PV as a strategic sector not only for supplying domestic demand but for supplying the rest of the world as well. The report highlights that by the end of 2021, global capacity for manufacturing wafers and cells exceeded demand by at least 100%. Furthermore, it is expected that by 2025, China's share of the global polysilicon, ingot and wafer production will have reached 95%. Sector experts indicate that due to the overcapacity and oversupply, Chinese-made products are offered at below-market prices. The increased focus on the EU market was nurtured by a high demand and buying power in the EU, given its renewable energy and net-zero ambitions, but also by protective measures of other trade blocks such as the Inflation Reduction Act in the United States and the production incentives in India.

10.2.1.5 Opportunities for expansion

Despite the challenges, there are some bright spots for EU firms in the solar value chain. The installation and maintenance of solar panels provide ample job opportunities, which is the

[689] ETIP Photovoltaics (2023) PV Manufacturing in Europe: understanding the value chain for a successful industrial policy - ETIP PV Industry Working Group White Paper, May 2023, p. 3-4, accessible from https://etip-pv.eu/publications/etip-pv-publications/download/pv-industry-white-paper-6

[690] Gervais, E., Kleijn, R., Nold, S., van der Voet, E. (2023) Risk-based due diligence in supply chains: The case of silver for photovoltaics, in Resources, Conservation & Recycling, vol. 198 (2023) 107148, accessible from: Risk-based due diligence in supply chains: The case of silver for photovoltaics - ScienceDirect

[691] The hotzone is the segment in the Cz-puller where the crucible is heated. They are made of different types of graphite and the setup is a very complicated process.

main reason why the sector association estimates that the sector employs around 800,000 people in the EU27.[692]

An inverter solar energy system is a type of solar power setup that includes an inverter, a crucial component that converts the direct current (DC) electricity generated by solar panels into alternating current (AC) electricity that can be used to power household appliances and feed into the electrical grid. Inverter production continues to dominate as the largest segment of solar manufacturing in Europe, boasting a production capacity exceeding 82 GW, marking a 14% increase from 2022's capacity of 72 GW. Presently, inverter manufacturers remain the cornerstone of solar employment within the EU. [608]

While competitive pressures led to the exit of some Western companies from the market, they also encouraged innovation among European firms, especially those already focused on innovation.[693] In this context, solar manufacturers in Europe have access to specialised photovoltaic (PV) research institutes across several countries. These include AIT in Austria, IMEC in Belgium, Fraunhofer ISE & CST, FZ Jülich, and ZSW in Germany, CEA-INES and IPVF in France, TNO in the Netherlands, and CSEM in Switzerland, among others. [608]Hopes are therefore focussed on new emerging technologies. Figure 70 provides an overview of the relative technological advantage position of solar PV and other renewable energy technologies for the EU27 in comparison to major economies. These scores are derived from scientific publications in Scopus across emerging renewable energy technologies for research institutes of the major economies. The authors indicate that at the country level, there is a positive correlation between publication activity in a particular subject and patent generation in that area. Hence, publication activity can be considered a leading indicator of future patenting and entrepreneurial potential. Figure 70 shows that in contrast to the position of wind energy, the lag in solar PV is substantial. The subareas where the EU has a global presence, though, are virtually all situated in integrated solar PV solutions.[694]

In addition, while some European companies active in the industry have declined production in the EU or stopped altogether, others have stepped in, including both established companies and entrants into the market.[608] Box 42 provides an example of startups being interested in taking over the production of an established company in financial distress.

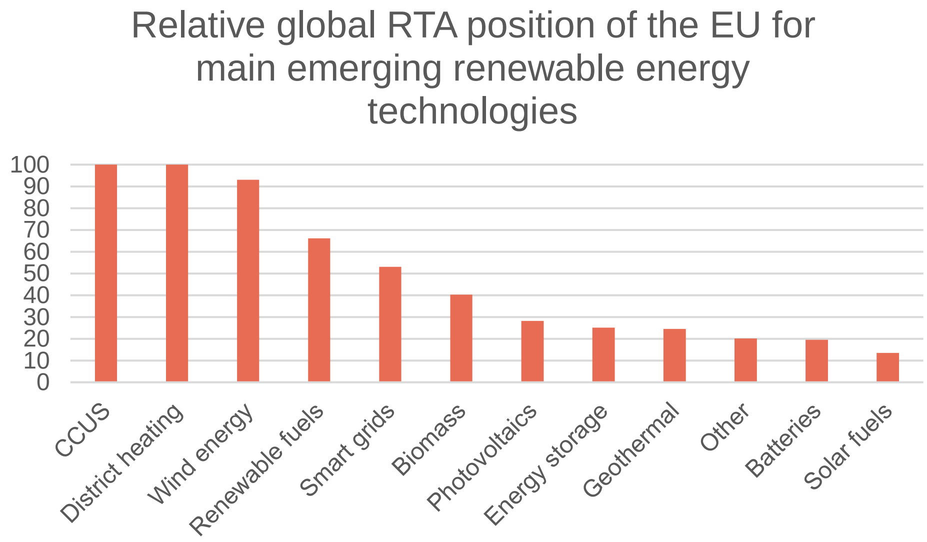
---

[692] https://www.solarpowereurope.org/insights/outlooks/eu-market-outlook-for-solar-power-2023-2027

[693] https://www.bruegel.org/policy-brief/smarter-european-union-industrial-policy-solar-panels#footnote13_azaqp9l

[694] More precisely: (i) Agrivoltaics; (ii) Bifacial perovskite solar cells; (iii) Hydrovoltaics; (iv) Indoor organic PV; (v) Offshore solar power; (vi) Perovskite/silicon tandem sol cells; (vii) Perovskite/silicon tandem sol cells; (viii) Tin perovskite solar cells; (ix) Vehicle integrated PV; (x) S-scheme heterojunction.

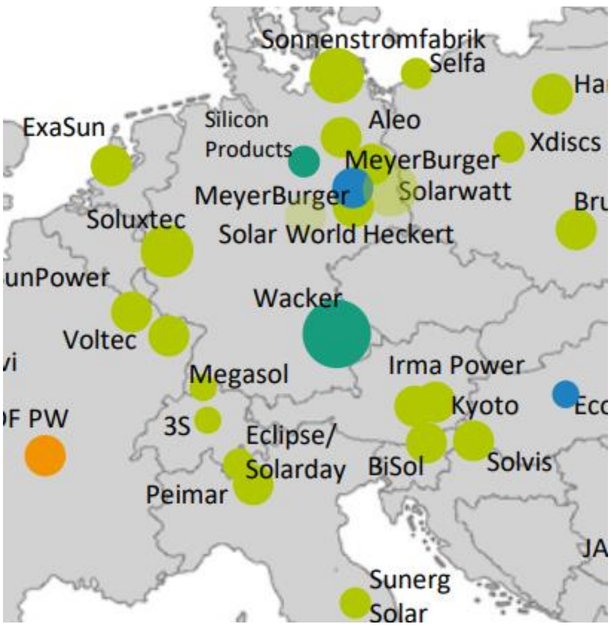
Figure 70: Relative technological advantage position of the EU against other major economies in the world for emerging renewable energy technologies.



Source: own calculations based on data from Annex 3 Eulaerts et al. (2024).

Note: A value of 100 indicates that Europe has for that energy technology the highest Revealed Technological Advantage (RTA) score as calculated by Eulaerts et al. (2024). A value less than 100 indicates Europe's RTA score as a percentage of the largest score of the other major economies. For instance, for the emerging fields in photovoltaics Korea has the highest RTA score: 3.69. Europe's score is 1.04. Hence Europe's relative RTA position is 28.18.

Box 42: Meyer Burger: A key solar PV manufacturer in Europe restructuring to survive



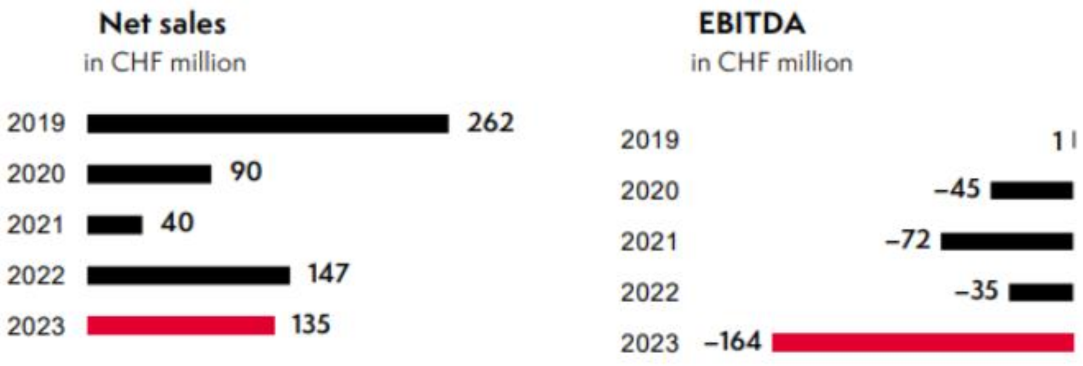
Source: Fraunhofer ISE (2023) Photovoltaics Report, Freiburg, 21 February 2023 p. 14

Note: blue: Cell manufacturers; light green: module manufacturers; dark green: polysilicon producers

Meyer Burger is one of the major Solar PV manufacturers in the EU with headquarters in Switzerland in Gwatt and production units in Switzerland, Germany and the United States. It produces solar cells and solar modules and has a substantial research and development division. Besides the headquarters, Switzerland hosts the research and technology subsidiary (Meyer Burger Research AG in Hauterive) and the subsidiary specialised in measurement technologies (Pasan SA, in Neuchâtel). The large-scale cell production is done by Meyer Burger GmbH in Bitterfeld-Wolfen (Thalheim), Germany. The solar cell production is mainly destined for the company's own solar module production in Freiberg, Germany. As such, Meyer Burger contains anintegrated production system with heterojunction solar cells from Bitterfeld-Wolfen being assembled in Freiber using its SmartWire connection technology which was developed in Switzerland. In 2023 approximately 1.4 GW of nominal annual cell and module production capacity was installed in Freiburg and Thalheim Germany. This corresponds to producing 1 million solar cells and 8,500 modules per day.

The company has sales offices in Europe, the United States., China, and Singapore. Europe represents more than 80% of net sales, the United States counted for 14% and Asia for 4%. In 2023 the total workforce was 1 294 FTEs of which 200 FTEs working in research and development[695]. In 2023 net sales declined substantially and profitability turned negative (Figure 71)

Figure 71 : Evolution of net sales and profitability between 2019 2023



Source : Meyer Burger (2024) Annual Report 2023, p. 11 available at 2023_Meyer_Burger_Annual_Report.pdf (meyerburger.com)

In its annual report for 2023, the management of Meyer Burger pointed to the "unprecedented distortions in the European Solar market", in particular, the use of dumping prices from Chinese suppliers in Europe in combination with a sharp rise in production overcapacity in China and a lack of market protection in Europe. The company states that to safeguard the company's survival in Europe and proactively respond to the negative market developments in the EU, it decided in February 2024 to close its module production site in Freiberg and move production to Colorado Springs in the United States. The solar cell production in Bitterfeld-Wolfen, however, would be maintained and supported by module production in the United States. The engineering and R&D sites in Switzerland and Germany are not affected.

The reasons for relocating the module production to the United States are the following: (i) promising market conditions in the US; (ii) stable cost base; (iii) fixed offtake agreements, and (iv) excellent price levels. Explicit reference is made to the US government support via the Inflation Reduction Act as an important factor that contributed to the market potential.

The company expects to generate an annual EBITDA of approximately 250 million CHF per year in the medium term from its business in the U.S.A. In their address to the shareholders, the Chairman Mr. Richter and the CEO Mr Erfurt conclude that given the high quality of their products and the company's technology roadmap that remains intact and promising, Meyer Burger is competitive and will reach profitability with its US sites.

In 2023, Meyer Burger Industries GMBH successfully applied for funding of EUR 200 million from the EU Innovation Fund[696]. The grants are for supporting the project "HOPE" which stands

[695] Meyer Burger (2024) Annual Report 2023, p. 11 available at 2023_Meyer_Burger_Annual_Report.pdf (meyerburger.com)

[696] Meyer Burger and NorSun Receive Financial Support from EU Innovation Fund - European Solar PV Industry Alliance (solaralliance.eu)

for High-efficiency Onshore PV module Production in Europe. The aim of the project was to establish an additional 3.5 GW production capacity for cells and modules in Germany[697].

Even though this case is indicative of the challenges the sector faces, startups like 1Komma5° and Enpal have expressed interest in taking over production. In other words, and pending the concrete follow-up, there is a possibility for new entrants to take the place of incumbents. However, challenges such as patent-protected technology and the absence of a political agreement on support for the German solar industry complicate the takeover. Most attention has been given to the production stages in public debate and policy making, especially in terms of reaching and contributing to the 600 GWac target of the EU Solar Energy Strategy. The decommissioning of existing panels has come to the forefront, especially in the context of circular economy policies and the alleviation of access to critical raw materials. Given that, on average, the longevity of solar PV panels is about 25 years, and that the majority of solar PV capacity was installed in the past decade (see also Figure 63), decommissioning and the accompanied waste streams will largely occur after 2030. According to Graulich et al. (2021) 95% of the solar PV mass can be recycled[698]. The authors estimate that by 2030 decommissioned solar PV volumes will exceed 1.5 million tonnes. This will likely create opportunities for EU firms, including SMEs, given their close proximity to an ample supply of installed panels.

Major applications for solar PV in Europe are rooftop solar panels for residential and commercial buildings as well as ground mounted systems for instance for utility-scale applications. However increasingly new avenues are tried and tested integrating solar PV in existing systems such as building-integrated solar PV, agri-photovoltaics, floating PV, vehicle-integrated PV, road integrated PV. Even when these are definitely interesting market niches, given the “commodised” nature of the components like cells and wafers it will remain challenging to become competitive on a global scale, as argued by the ETIP Photovoltaics in its May 2023 report[699].

10.2.2 OSA goals and overview of relevant policy initiatives

The EU endeavours to bolster the revival of regional solar manufacturing through diverse funding mechanisms. This initiative aims to foster resilience, promoting the adoption of solar energy as a pivotal component in Europe's trajectory towards a sustainable, carbon-neutral energy framework.

The EU has initiated policies and formed alliances to stimulate the production of photovoltaic (PV) panels and enhance its broader value chain. A key initiative is the **European Solar Photovoltaic Industry Alliance**, launched to scale up manufacturing technologies for innovative solar PV products and components. This alliance is part of the broader EU Solar Energy Strategy, which aims to significantly increase the EU’s solar photovoltaic capacity, targeting over 320 GW by 2025 and nearly 600 GW by 2030. The strategy and alliance are responses to the need for energy diversification and strategic autonomy in the solar sector, particularly to reduce dependence on imports and foster a "Made in Europe" solar value chain by identifying manufacturing bottlenecks, facilitating access to finance, supporting research and innovation, and promoting sustainability and circularity in the solar industry.The Alliance hosts more than 130 members, covering the entire triple-helix stakeholder range from

697 HOPE - High-efficiency Onshore PV module production in Europe - European Solar PV Industry Alliance (solaralliance.eu)

698 Graulich, K., Bulach, W., Betz, J., Dolega, P., Hermann, C., Manhart, A., Bilsen, V., Bley, F., Watkins, E., Stainforth, T. (2021) Emerging waste streams - Challenges and opportunities, Freiburg, February 2021, 89 pp, accessible from https://www.oeko.de//fileadmin/oekodoc/EEA_emerging-waste-streams_final-report.pdf. Technically possible recycling rates are

699 ETIP Photovoltaics (2023) PV Manufacturing in Europe: understanding the value chain for a successful industrial policy - ETIP PV Industry Working Group White Paper, May 2023, p. 14, accessible from https://etip-pv.eu/publications/etip-pv-publications/download/pv-industry-white-paper-6

enterprises, manufacturers, off-takers, installers, business associations, to research institutes and universities.

In March 2023, the Commission launched the **Big Buyers Working Together (BBWT)** Community to support the collaboration between public buyers and, at the same time, promote the use of strategic public procurement for innovative and sustainable solutions. The BBWT contains a platform and ten **Communities of Practice (CoPs)**, one of which is focused on sustainable solar panels. The idea is to have regular meetings with public buyers, making study visits, market dialogues, pitching sessions from producers, and meeting with industry associations to bridge the gaps between capacity and the CoP's demands. In the CoP for Sustainable Solar PV information is spread about topics like the longevity of modules, degradation, toxics, and the carbon footprint to the potential public buyers.

The **Net-Zero Industry Act** specifies that in order to secure supply and support resilience of the EU's energy system, the net-zero technology operational manufacturing capacity for solar wind energy should be at least 30 GW by 2030[700]. Similar to the wind energy value chain, important policy initiatives have to be listed that helped prepare the EU energy market for the integration and deployment of renewable energy, and fostered the creation of a lead market for renewables. These include the launch of the European Strategic Energy Technology Plan (SET Plan) in 2007, the set-up of the Energy Union in 2015, the 'Fit for 55' Package, the EU Green Deal and more recently, the REPowerEU, the Green Deal Industry Plan, launched on 1 February 2023.

As part of the REPowerEU plan to phase out the dependence on fossil fuels in response of Russia's invasion of Ukraine and hence to accelerate the deployment of climate neutral technologies, the **Solar Energy Strategy**[701] was set-up to foster the rollout of solar PV in Europe. The intention of the Strategy is to double the solar photovoltaic capacity by 2025, which is 320 GW newly installed photovoltaic capacity, and to install 600 GW new capacity by 2030.

It was estimated that between May 2022 and 2027 26 billion EUR would be needed on top of the investments under '**Fit for 55' Package**. The Commission indicated that most of the investment will come from private sources. Yet public funding is used to trigger private investments. The Strategy explicitly mentions the Recovery and Resilience Facility, which has 19 billion EUR dedicated to the rollout of renewable energy. Other financial instruments are e.g. the cohesion funds, InvestEU, the Innovation Fund, Horizon Europe, LIFE programme. Cross-border cooperation between Member States for solar energy projects can be supported by the Connecting Europe Facility RES. The Strategy points to the responsibility of Member States to identify and valorise synergies with existing funding programmes and the application of cascade funding, e.g., aiming to promote research and development and the EU renewable energy financing mechanism. The MS can also make use of the support via the Technical Support Instrument to accelerate the deployment of solar energy. Within the global competitive context, Member States can use the new Guidelines on State aid for climate, environmental

[700] European Commission (2023) Proposal for a regulation of the European Parliament and of the Council on establishing a framework of measures for strengthening Europe's net-zero technology products manufacturing ecosystem (Net Zero Industry Act), Brussels, 16.03.2023 COM(2023) 161 final, pp. 21-22. It contains four initiatives: (i) The Solar Rooftop Initiative which purposed to gradually oblige the installation of solar panels on new pubic and commercial buildings, as well as residential buildings; (ii) The Commission's permitting package which contains legislative proposals, recommendations and guidance to make permitting procedures shorter and simpler. On the legislative side this is incorporated in the revised Renewable Energy Directive (EU/2023/2413); (iii) EU large-scale skills partnership, to ensure the availability of a skilled workforce needed for both producing and deploying solar energy across the EU. The Partnership brings together relevant stakeholders in order to take action for upskilling and reskilling the current workforce; (iv) The EU Solar PV Industry Alliance focussing on reenforcing the current solar PV value chain with innovation-led expansion towards a resilient industrial solar value chain with particular focus on manufacturing.

[701] European Commission (2022) Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, EU Solar Energy Strategy, Brussels, 18.05.2022, COM(2022) 221 final, accessible from EUR-Lex - 52022DC0221 - EN - EUR-Lex (europa.eu)

protection, and energy, which introduced a set of criteria for proportionate support for renewable energy including solar PV.

The EU Solar Energy Strategy included instruments focussing on green public procurement, i.e. the **Big Public Buyers** initiative, and the application of the **Ecodesign Directive** and **Energy Labelling Regulation** to solar PV systems, for instance, to ban solar panels from the EU Single Market that were made using child or forced labour. The EU Solar Energy Strategy refers to SMEs only once, referring to the possibility of benefiting from solar PV solutions, alongside citizens, and communities, thereby reducing the reliance on natural gas. The underlying assumption seems to be that promoting the entire solar PV sector will ultimately be beneficial for SMEs as well.

Levelling the global playing field for solar PV manufacturing is currently a key concern for EU manufacturers. As indicated above, the application of the Ecodesign Directive and the Energy Labelling Regulation can be instrumental in this regard. Another piece of legislation is the Foreign Subsidies Regulation. The **Foreign Subsidies Regulation** came into force on July 12 2023. It enables the European Commission to investigate and address distortions caused by foreign subsidies, which in turn should provide a more level playing field for companies operating in the EU27 internal market, while keeping the possibilities of trade and investment on a global scale. On 3 April 2024, the European Commission opened two in-depth investigations in the context of the Foreign Subsidies Regulation in solar photovoltaics to assess whether and to which degree suppliers made unfair bids using foreign subsidies to win a public tender for a 110 MW photovoltaic park in Romania (Parc Fotovoltaic Rovinari Est) 702. The development of the park was partly financed by the EU Modernisation Fund. The two consortia investigated were i) ENEVO-LONGi Solar Technologie, where the latter is ultimately fully controlled by LONGi Green Energy Technology Co., Ltd listed on the Hong Kong Stock Exchange, and ii) Shanghai Electric UK Co. Ltd. And Shanghai Electric Hong Kong International Engineering Co. Ltd both of which are fully owned and controlled by the state-owned enterprise Shanghai Electric Group Co. Ltd.

10.2.3 Recommendations for future policy actions

The following recommendations for SMEs operating in the EU solar PV manufacturing value chain stem from the considerations in the previous sections.

Reaching minimum (financial) sustainable production scale by ensuring access to finance. In a world where production scale is the key determinant of cost-competitiveness it is imperative that start-ups and existing SMEs active in the solar PV industry will scale-up rapidly. Failing to do so will structurally hamper the viability of SMEs, often well-intended for co-reaching the climate ambitions and with smartly engineered products. Therefore, it is crucial to continue and substantiate public financing programmes to sustain what is left of the EU solar PV value chain and to optimally use the specific SME-focused instruments such as COSME and the several SME-specific instruments that are used in the MS.[703]

Keeping pace with innovations and ability to incorporate or absorb the results of Member State and EU-funded research into commercially viable products and services via a more effective public procurement, involvement of actors such as universities and competence centres, and expanding the market for recycling used solar panels.

- **Green public procurement (GPP) has often been mentioned by interviewees and experts in the solar PV sector as an important part of the solution**. In combination

[702] European Commission (2024) Commission opens two in-depth investigations under the FSR (europa.eu) accessed April 3rd, 2024.

[703] The large integrated solar PV companies in Asia, particularly China, allocate research budgets on solar PV that are a multiple of the funds spent in the EU via the Horizon2020 and Horizon Europe programmes together

with the applications of Ecodesign Directive for solar PV modules, ESG due diligence, and including full life cycle costing parameters, promoting GPP might indeed be an advantageous policy for EU solar PV manufacturing. Although the GPP market in Europe is enormous, its implementation remains cumbersome, specifically due to the technical nature of the procedures and, in the case of solar PV, the product. The challenge remains the speediness of the implementation, especially when confronted with the challenging situation in which EU solar PV manufacturers are faced with in 2023-2024, and probably beyond. The NZIA (art. 19) allowed for giving more weight to non-price criteria in public purchases. SMEs are often focused on local markets. Moreover, local authorities tend to be uninformed about strategic GPP, let alone the technicalities and complexities of the GPP processes. Far too often, price remains the key decision criterion. Hence, the authorities of all levels in the EU must understand the intricacies of GPP and apply it effectively, making strategic purchases, not only to benefit their constituency but also by providing a valuable home market to the solar PV enterprises in Europe, both small and big.

On top of that, GPP policies can also be mainstreamed across the EU by achieving a common understanding of green public procurement practices and adopting experiences more widely. Therefore, as an inspiration for policy makers, a Joint Catalogue[704] has been issued with policies, practices, and actions across all phases of the procurement process. Green and social criteria could favour domestic producers over foreign ones. As a case in point, countries like Italy have incorporated mandatory Minimum Energy and Environmental Sustainability Criteria (MEC) in public procurement to ensure that purchased products and services, including those related to solar energy, meet high environmental and energy efficiency standards.

- **To increase SMEs' innovation capacity, it is important not to lose the innovation track and to continue to valorise innovative solutions in new niche markets.** The new technology pathways for integrated solutions such as building-integrated PV, agri-photovoltaics, road-integrated PV, floating PV, vehicle-integrated PV are promising routes, as well as digitalisation, repowering, new grid stabilisation features, the optimisation of self-consumption, storage, innovative semiconductor for efficient and compact designs, to name a few. Patenting and protection of intellectual property rights can be costly for SMEs and is, therefore, not always the preferred strategy in comparison to keeping the knowledge tacit and inhouse. Therefore, **intermediaries such as university tech transfer offices, government agencies focussed on promoting SMEs, or specialised cluster organisations are very important to foster the application of innovative solutions in the solar PV SMEs, and helping anchor the knowledge and technologies in the SMEs** and potentially in its company value chain. These intermediaries may also function as liaisons to provide wider networks, both upstream and downstream. Last but not least, helping to secure financial support and showing the way in the myriad of potential government support schemes will provide valuable support to solar PV SMEs and increase their chances to compete in the market.
- The **market for recycling used solar panels** is in full expansion and is likely to grow even further over the coming years. Given the vast deployment of panels in the EU, this represents an opportunity for European firms. As the process is complex and technical, **R&D support schemes are welcome to expand the market.** The industry also made suggestions to reform the EU Waste Framework Directive so as to improve the regulatory environment. Already in 2022, around 8% of jobs in the sector are

[704] Bloch, D. (2024) Joint EU-US Catalogue of Best Practices on Green Public Procurement, April 5, 2024, accessible from Circabc (europa.eu)

focused on recycling activities, a number that is projected to increase substantially over time. RESiLEX, funded by HorizonEurope, is a project to explore the potential for recycling in the Belgian market, with applications for battery production, among others. This is typically done by specialised companies. These are either active already in the broader recycling industry or typically young and small companies with a specific focus on solar panels (but with considerable scale-up potential). In France, for example, Veolia, a multinational company, and ROSI Power, a start-up from 2017, are both active in the decommissioning and recycling of solar panels.[705]

Ensuring a level playing field both globally and locally by liaising with partners sharing a common workable set of values while pursuing open strategic autonomy.

- The EU could establish partnerships with countries outside of China to decrease dependence, including regulatory and policy alignment and ideally a carbon pricing system. García-Herrero et al. (2023)[706] advocate a '**green tech partnership**' with '**incentive-aligned**' governments and businesses to decarbonise economies faster, ensuring greater diversification of resources and supply. The authors indicate that the ultimate purpose of the partnership is not to substitute for the Chinese supply chain, since this would jeopardize meeting the net-zero ambitions globally. It is the authors perception that the current EU strategy as laid down in the Green Deal Industrial Plan legally anchored in 1) diversifying supply sources via the Critical Raw Material Act and 2) reshoring manufacturing in Europe through the Net-Zero Industry Act will most likely not be feasible within the time foreseen and hence without further actions would lead to more expensive clean tech solutions and solar PV in particular. Given that solar PV manufacturing costs in South-East Asia and India are substantially lower than those in the United States and the EU, extending partnerships with these countries can be beneficial and help de-risking and fostering the EU's solar PV manufacturing. Partnership should involve the US as a major driver of market demand for green technology solutions backed up with a strong innovation and finance capacity, together with resource-rich countries and low-cost manufacturers around the globe. Creating an Atlantic market space that is closer aligned to the EU Single Market for solar PV would definitely provide a more positive perspective for the current manufacturers in the EU as well as for the entire value chain and its investors. Undoubtedly differences in relative competitive advantages between the USA and Europe will still come to into play. However, with a combined solar PV market potential more weight would be put in the balance to level and diversify the global market situation.[707]
- **Local content requirements may also be a relatively non-distortive manner to stimulate the domestic industry when coupled with subsidy or tax credit schemes.** In the US, for example, renewable energy projects can qualify for the 10% domestic content tax credit rider created by the Inflation Reduction Act, only if stringent local content requirements are met.[708]A minimum percentage of manufactured products need to be sourced from the US to be eligible, and the tax authority must provide detailed guidance on what this entails in practice. Similar requirements could be applied at the EU level (it would not make sense in individual EU MS).

[705] https://www.solarpowereurope.org/press-releases/how-is-belgium-transforming-old-solar-panels-into-next-generation-batteries-for-the-future-of-e-mobility and https://www.linkedin.com/pulse/solar-panels-life-after-death-2023-guide-panel-recycling-avgue/ and https://www.technologyreview.com/2021/08/19/1032215/solar-panels-recycling/

[706] García-Herrero, A., Grabbe, H., Kaellenius, A. (2023) De-risking and decarbonising: a green tech partnership to reduce reliance on China, in Policy Brief Issue nr. 19/23, October 2023, available from: De-risking and decarbonising: a green tech partnership to reduce reliance on China (bruegel.org)

[707] To give an example, in May 2023 , the Transatlantic Initiative on Sustainable Trade work programme (TIST) was launched to accelerate the transition to climate-neutral economies in the EU in a mutually beneficial manner.

[708] https://www.irs.gov/newsroom/irs-provides-initial-guidance-for-the-domestic-content-bonus-credit

The EU could possibly **introduce trade measures** to complement the above measures, following the example set by the US. In 2018, safeguard tariffs were first introduced on imported crystalline silicon solar panels by the Trump administration, aimed at bolstering domestic solar panel manufacturing. These tariffs imposed a 30% duty in 2018, with subsequent step-down rates of 25% in 2019, 20% in 2020, and 15% in 2021. Additionally, the first 2.5 GW of imported solar cells for U.S. panel assemblers were tariff-free each year. President Joe Biden has extended these safeguard tariffs for another four years in 2022.[709] The safeguard measures, particularly the extension announced in 2022, have stimulated domestic production activities. Several firms have announced plans to start CSPV cell production in the near future, which has also been driven by the incentives under the Inflation Reduction Act (IRA). This is expected to enhance the local manufacturing capacity of CSPV cells. Prior to 2018, the EU imposed trade restrictions on imported solar panels, but abandoned this policy as it was perceived as not very helpful to support the EU industry, while raising the cost to realise the green ambition.[710] The reimposition of trade measures could nonetheless be considered as a possible option and is currently the subject of an investigation by the Commission.

[709] https://www.solarpowerworldonline.com/2024/02/usitcs-midterm-report-on-sec-201-solar-tariffs-heads-to-president/
[710] https://www.bruegel.org/policy-brief/smarter-european-union-industrial-policy-solar-panels#footnote13_azaqp9l

GETTING IN TOUCH WITH THE EU

In person

All over the European Union there are hundreds of Europe Direct information centres. You can find the address of the centre nearest you at: european-union.europa.eu/contact-eu/meet-us_en

On the phone or by email

Europe Direct is a service that answers your questions about the European Union. You can contact this service:

– by freephone: 00 800 6 7 8 9 10 11 (certain operators may charge for these calls),

– at the following standard number: +32 22999696, or

– by email via: european-union.europa.eu/contact-eu/write-us_en

FINDING INFORMATION ABOUT THE EU

Online

Information about the European Union in all the official languages of the EU is available on the Europa website at: european-union.europa.eu

EU publications

You can view or order EU publications from: op.europa.eu/en/publications. Multiple copies of free publications can be obtained by contacting Europe Direct or your local documentation centre (see european-union.europa.eu/contact-eu/meet-us_en).

EU law and related documents

For access to legal information from the EU, including all EU law since 1952 in all the official language versions, go to EUR-Lex at: eur-lex.europa.eu

Open data from the EU

The portal data.europa.eu provides access to datasets from the EU institutions, bodies and agencies. These can be downloaded and reused for free, for both commercial and non-commercial purposes. The portal also provides access to a wealth of datasets from European countries.

ET-09-24-498-EN-N

Publications Office
of the European Union

doi: 10.2873/45743
ISBN 978-92-68-18114-0