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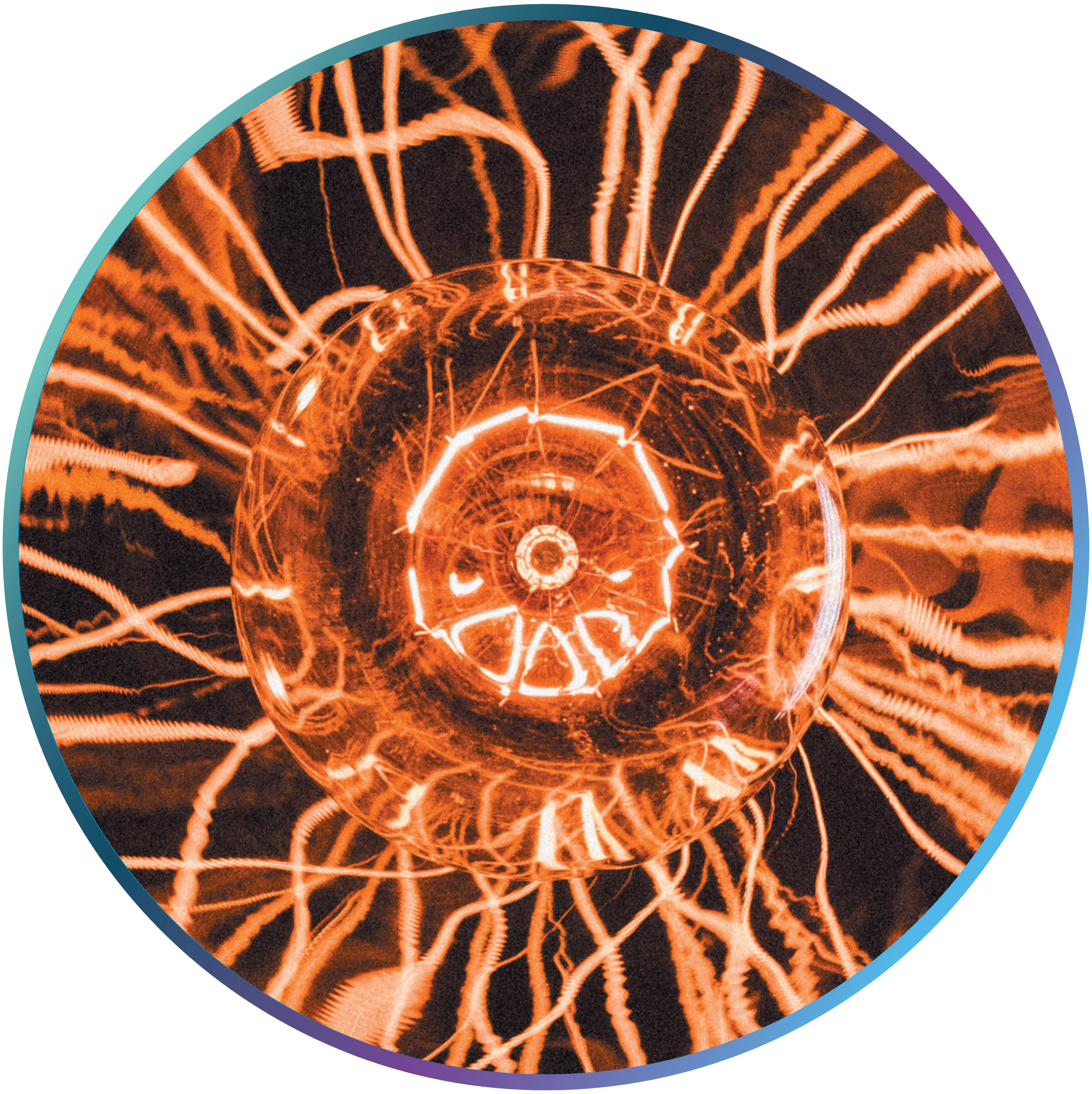
Ensuring resilience in Europe's energy transition

The role of EU clean-tech manufacturing

ANALYSIS



Ensuring resilience in Europe's energy transition

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Ensuring resilience in Europe's energy transition: The role of EU clean-tech manufacturing

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Preface

Dear reader,

Europe relies to a high extent on imports of clean technologies such as solar PV or batteries. Recent events show that it would be naive to take the secure supply of critical raw materials, of refined materials, of components or final clean-tech products for granted.

Minimum shares of EU clean-tech manufacturing could – next to supply diversification and enhanced recycling – function as insurance in clean-tech value chains.

But what would be appropriate minimum shares of EU manufacturing in different clean-tech value chains? And what measures seem suitable to incentivise the establishment of clean-tech manufacturing in Europe? These questions are currently hotly debated in Europe, in view of the demand pull by the US Inflation Reduction Act and rising trade tensions between the US and China.

Based on an analysis by Roland Berger, we recommend a package of measures for scaling EU clean-tech manufacturing so that it makes a lasting contribution to the resilience of Europe's clean energy transition.

Enjoy the read!

Matthias Buck,
Director Europe, Agora Energiewende

Frank Peter,
Director, Agora Industry

Key findings at a glance:

1. **Europe's transition to climate neutrality requires a fast increase in the annual deployment of clean technologies, in particular solar PV, onshore and offshore wind, batteries, heat pumps and electrolysers.** However, Europe cannot take the smooth functioning of international clean-tech value chains for granted but should make them more resilient. More resilience will result from diversifying supplies through domestic mining and strategic international partnerships, by enhancing material circularity and by increasing clean-tech manufacturing in Europe.

2. **The analysis identifies minimum shares of EU clean-tech manufacturing as an insurance against supply chain risks.** Estimated public funding needs for scaling EU manufacturing to these levels are between 10–30 billion euros until 2027 and 32.9–94.5 billion euros from 2028 until 2034, with a significant share required to reduce operational cost. Indicative technology-specific targets set in the Net Zero Industry Act for batteries, wind and electrolysers are higher and would require more public funding.

3. **A credible approach to closing the production cost gap is essential for scaling clean-tech manufacturing in Europe, to reach critical scale and develop local supply networks.** To ensure long-term competitiveness without support, dedicated public funding should be part of a broader policy package that covers access to finance, competition on quality (including sustainability), a robust clean-tech demand pipeline and investment into innovation.

4. **EU countries should recognise the necessity to cooperate with technology and value chain leaders and seek to attract leading clean-tech suppliers to establish manufacturing in Europe.** To achieve a gradual de-risking of current value-chain dependencies, support offers should, however, be accompanied by safeguards that ensure a lasting commitment of companies deciding to establish production in Europe.

Content

Content

1 Executive Summary

The EU's transition to climate neutrality requires the rapidly accelerated deployment of clean technologies such as solar PV, wind (on- and offshore), batteries, heat pumps and electrolysers over the next twenty years. However, Europe cannot take the smooth functioning of international clean-tech value chains for granted but should make them more resilient.

Against this background, the EU Commission has proposed several policy initiatives to address the tension between Europe's massive demand for clean technologies and growing global competition over raw and refined materials in the context of increased economic uncertainty. This includes legislative proposals for a Net Zero Industry Act and for a Critical Raw Materials Act, a further relaxation of EU state aid rules and EU funding to support needed investments. Indicative targets for EU manufacturing play a central role in these initiatives.

To support informed decisions on priority-setting and potential trade-offs, Agora Energiewende commissioned Roland Berger to:

- → Analyse important clean-tech value chains to identify relevant dependencies for raw materials, from refining and components to final products;
- → Establish which levels of EU domestic manufacturing would seem appropriate to make the analysed clean-tech value chains more resilient; and
- → Quantify – for different scenarios – the relevant additional costs (private or public).

A key finding of Roland Berger's analysis is that **any effort for scaling clean-tech manufacturing in Europe beyond current levels requires a credible approach for closing the opex gap, since clean-tech manufacturing in Europe is more expensive than in other countries**, mostly due to higher labour and energy costs.

However, cost (and opex cost in particular) is only one dimension of competitiveness for clean technologies and Europe must not seek to compete on cost alone. Nevertheless, in some sectors, such as solar PV or the processing of critical raw materials, the cost gap is a key factor hindering the establishment of competitive clean-tech manufacturing in Europe. This issue is not sufficiently addressed in the Net Zero Industry Act, the Critical Raw Materials Act or related EU funding.

A policy package to ensure that scaling of clean-tech manufacturing in Europe makes a lasting contribution to the resilience of Europe's clean energy transition

Scaling EU manufacturing of clean technologies to minimum levels and specifically targeting important vulnerabilities would act as insurance against risks to clean-tech value chains. However, dedicated public funding to scale clean-tech manufacturing in Europe should be embedded in a broader package of policies to ensure long-term competitiveness without support.

Specifically, we recommend complementing the Net Zero Industry Act and the Critical Raw Materials Act with the following seven elements to ensure that efforts to scale EU clean-tech manufacturing make a lasting contribution to the resilience of Europe's clean energy transition:

1. **A Clean-Tech Manufacturing Fund** for closing the opex and capex cost gaps;

2. **A clean-technology manufacturing contribution** to provide revenues for the fund;

3. **Privileged access to favourable investment and finance costs,** to shorten the payback period on

investments in new manufacturing sites and facilitate larger-scale investments;

4. **Market differentiation of EU-manufactured clean-tech products** through mandated reporting on the sustainability of clean technologies and critical raw materials sold in Europe;

5. **Long-term demand creation for EU-manufactured clean-tech products, based on superiour sustainability performance**, by systematically linking public procurement decisions and public support for private investment to superiour sustainability performance, not only the cheapest price;

6. **Attracting leading clean-tech suppliers to establish manufacturing in Europe**, while using safeguards to achieve a gradual de-risking of value-chain dependencies; and

7. **Investment into strategic innovation projects in clean-tech sectors**, to build on the high innovative potential of European companies and ensure the long-term competitiveness of clean-tech manufacturing in Europe.

A dedicated and coordinated EU industrial policy response would add to the resilience of Europe's clean energy transition, but also create jobs and other benefits. Maintaining a strong clean-tech production base, for instance in the wind industry, would create demand for other manufacturing products. And the creation of a strong domestic battery manufacturing sector would ensure that jobs and value added in the automotive industry will be retained in Europe during the transition to electric mobility. Particularly for nascent industries like batteries or electrolysers, timely intervention is essential because of path dependencies in industrial development. Catching up later would be more expensive, if possible at all, because international competitors have in the meantime gained technical expertise and economies of scale and potentially achieved a dominant position in future markets.

Elements that determine the resilience of clean-tech value chains

The resilience of clean-tech industrial value chains is the result of several related elements: the respective level of EU manufacturing and domestic supplies, the existence of diverse international suppliers for critical materials or components and effective policies to advance circular uses or the substitution of materials and components.

Efforts to increase the resilience of clean-tech industrial value chains will need to be tailored to each value chain. They should be based on a robust analysis of the status quo and a mapping of the main risks, expected sector developments and suitable measures for increasing resilience.

Against this background, the report describes the status quo, main risks and expected sector developments for five important clean technologies: solar PV, wind (on- and offshore), electrolysers, heat pumps and batteries.

Minimum shares of EU manufacturing can serve as an insurance against value chain risks

EU manufacturing is just one lever for strengthening the resilience of clean-tech value chains (see above). However, considering the focus of debates on the proposed Net Zero Industry Act and the Critical Raw Materials Act, the main focus of our analysis is on identifying minimum shares of EU manufacturing to enhance the resilience of value chains for solar PV, wind (on- and offshore), electrolysers, heat pumps and batteries.

For each step in each value chain, existing economic, geopolitical, technological, geographical and digital risks are identified and quantified. An overall risk score for each technology value chain then allows the calculation of minimum shares of EU manufacturing per technology or subcomponent.

However, since industrial value chains are only as resilient as their most vulnerable element, this calculation is enriched with information on particularly critical risks that could disrupt an entire chain. For example, the wind industry value chain is currently highly dependent on the supply of permanent magnets, which require rare elements as input, for which Chinese companies have a dominant market position both for materials extraction and for refining.

Most of the minimum EU manufacturing shares resulting from our analysis are below the indicative targets in the proposed Net Zero Industry Act. These differences do not seem to reflect different understandings of value chain risks and vulnerabilities, but rather a different approach to identifying desirable shares of EU manufacturing. Whereas the methodology developed by Roland Berger focuses on value chain resilience and is based on a quantification of value chain risks, the indicative targets in the Net Zero Industry Act proposal blend resilience considerations with classic industrial policy objectives (e.g. technology leadership, securing market shares and industrial jobs).

The EU minimum manufacturing shares resulting from Roland Berger's calculations should thus be understood as the minimum insurance Europe needs to contain the risk that its transition to a net-zero economy will be delayed or derailed. There may be convincing industrial policy objectives to aim for higher manufacturing shares for specific technologies. Policy-makers could, for instance, decide to maintain a strong European wind industry that is able to expand in international markets, as this may open strategic opportunities to cooperate, for instance, with countries that have privileged access to raw materials.

Different scenarios for increasing EU manufacturing shares come with different additional costs per technology for investments and for manufacturing

Roland Berger used the different levels of EU clean-tech manufacturing for calculating the respective additional costs for required investments and manufacturing.

A **baseline scenario** for each technology reflects the current manufacturing base, with growth based on a conservative projection of project announcements.

A **NZIA scenario** quantifies the additional costs for reaching domestic manufacturing thresholds as proposed by the EU Commission in the Net Zero Industry Act and related documents.

Two resilience scenarios seek to quantify differences between two principled approaches to achieving resilience: an **EU-coordinated resilience approach** and a **nationally driven resilience approach**. Each scenario calculates the additional costs to achieve an EU manufacturing base that meets the minimum market shares derived from the risk analysis, but the scenarios differ in how this is achieved.

Total costs, including both capital and operating manufacturing expenditures, are increasing with the level of ambition in re-shoring clean-tech value chains, but there is a significant cost difference between the resilience scenarios developed by Roland Berger on the one hand and the total costs for achieving the indicative targets under the proposed Net Zero Industry Act on the other.

Across all scenarios, operational expenditures make up a significant share of total costs (~70 percent), compared to capital expenditures and reinvestments (~30 percent). This has consequences for suitable support measures.

The additional costs per additional unit of manufacturing in Europe differ significantly across technologies. To achieve manufacturing levels of the resilience scenarios, 71 percent would be for scaling battery manufacturing and 21 percent for solar PV, with much smaller additional costs for scaling wind, electrolyers and heat pumps.

Specifically for the wind industry, it seems important to underline that the calculated cost difference between the indicative targets in the proposed Net Zero Industry Act and the resilience scenarios developed by Roland Berger is small (8.8 billion euros). However, scaling battery manufacturing in Europe to levels beyond those recommended from an insurance perspective would incur much larger additional costs.

Different measures to compensate for the cost disadvantage of clean-tech manufacturing in Europe would require different amounts of public funding

Expanding or maintaining EU clean-tech manufacturing beyond the level the market would deliver without interventions requires a robust policy framework that will come at a cost for consumers and taxpayers. Core measures available are local content requirements, import tariffs, opex subsidies, capex grants and public procurement.

Local content requirements and import tariffs seem attractive, as additional costs for manufacturing in Europe would fall on clean-tech buyers rather than on public budgets. However, such measures also come with significant political and economic risk, most importantly potential international trade conflicts that would likely include costly retaliatory measures from trading partners.

The alternative measures (opex support, capex grants, public procurement) come with a lower burden and lower risks for the economy, but with a larger burden on public budgets.

For the purpose of this analysis, we assume that EU policy-makers will rely on measures that eliminate the cost disadvantage of EU manufacturers rather than impose costs on EU consumers and investors through "Buy European" regulation or import tariffs.

Estimated public funding needs for scaling EU manufacturing to minimum insurance levels are between 10–30 billion euros until 2027 and 32.9–94.5 billion euros from 2028 to 2034

We assume for the calculation of public funding needs that investment costs are supported between 20 and 40 percent, depending on the sector, and that opex is supported in a way that eliminate most of the cost gap of EU producers relative to the most competitive foreign producer in the sector. No specific instrument for opex support is assumed, but it can include tax credits, contracts for difference or public procurement with local content requirements.

We calculate EU- and national-level funding requirements for both the EU-coordinated scenario and the nationally driven scenario. The estimated EU-wide fiscal costs for both scenarios are between 164–180 billion euros in the two scenarios for 2022–2034, which is in line with existing estimates of public spending needs of the US Inflation Reduction Act.

It is furthermore important to note that public funding needs in the current EU budget period (2021–2027) are significantly smaller than in the next EU budget period (2028–2034): 30 billion euros versus 94.5 billion euros, with the cost of opex support rising almost fivefold as all plants are fully operational and demand for clean-tech products reaches higher levels.

Public funding to increase EU clean-tech manufacturing would come on top of much larger public funding needs to accelerate the deployment of clean technologies in Europe

Even if they are significant, the public funding needs to strengthen the resilience of EU clean-tech value chains are small compared to those on the technology deployment side. If the scaling of clean-tech manufacturing in Europe would come at the expense of public funding available for supporting the deployment of clean technologies in line with Europe's pathway to climate neutrality, then a "green industrial policy" would undermine rather than support the EU Green Deal.

2 Introduction

The EU's transition to climate neutrality requires the rapidly accelerated deployment of clean technologies such as solar PV, wind (on- and offshore), batteries, heat pumps and electrolysers over the next twenty years.[1]

The COVID-19 pandemic and Russia's war of aggression against Ukraine have put a spotlight on the vulnerability of globally integrated clean-tech value chains and show that the secure supply of critical raw materials, of refined materials, of components or of final products cannot be taken for granted. These concerns are exacerbated by growing political rivalry between the US and China that could disrupt international trade, as well as by the US Inflation Reduction Act, which offers generous tax breaks to companies that produce and sell clean technologies in the US.

Against this background, the EU Commission presented in February 2023 the Green Deal Industrial Plan[2] that announced several policy initiatives to address the tension between Europe's massive demand for clean technologies and growing global competition over raw materials and skilled personnel in the context of increased economic uncertainty, including:

→ a Net Zero Industry Act[3] to establish a simplified regulatory framework for scaling domestic production capacity of clean lead technologies;
→ a Critical Raw Materials Act[4] to secure EU access to critical raw materials through diversified sourcing, enhanced circularity, facilitated extraction and innovation to reduce or substitute materials use;
→ a relaxation of EU state aid rules[5] to simplify national subsidies for clean-tech investments in Europe; and
→ a re-prioritisation of existing EU funding and the establishment of a European Sovereignty Fund to support needed investments.

Legislative debate on these important proposals is ongoing, while due to the rushed nature of these initiatives only little research exists to support informed decisions on priority-setting and potential trade-offs. Against this background, Agora Energiewende commissioned Roland Berger to:

→ Analyse important clean-tech value chains to identify relevant dependencies for raw materials, from refining and components to final products;
→ Establish which levels of EU domestic manufacturing would seem appropriate to make the analysed clean-tech value chains more resilient; and
→ Quantify – for different scenarios - the relevant additional costs (private or public).

In the following, we first present important insights from the Roland Berger analysis and then discuss – in view of the Green Deal Industrial Plan – the effectiveness of different policy measures to scale EU clean-tech manufacturing. We calculate cost implications for public and private budgets, quantify the necessary contributions through public funding from EU or national budgets under different assumptions of EU-level cooperation and show resulting challenges for different regions in Europe.

The paper concludes with recommendations on priority-setting in policy debates around the Green Deal Industrial Plan.

1 E.g. Agora Energiewende (2023), Breaking Free from Fossil Gas. A new pathway to a climate neutral Europe; IEA (2021), Net Zero by 2050, IEA Paris.

2 COM(2023) 62 final of 1.2.2023.

3 COM(2023) 161 final of 16.3.2023.

4 COM(2023) 160 final of 16.3.2023.

5 Temporary Crisis and Transition Framework for State Aid measures to support the economy following the aggression against Ukraine by Russia (2023/C 101/03) of 17.3.2023.

3 Elements determining the resilience of industrial value chains

Resilient industrial value chains are important for Europe's transition to climate neutrality, as the transition rests on the rapid scaling of clean technologies such as solar PV, wind turbines (onshore and offshore), batteries, heat pumps and electrolysers. Figure 1 shows the required deployment of clean technologies to set Europe on a path towards climate neutrality in line with the EU Climate Law and measures enshrined in the Fit for 55 policy package.[6]

Figure 2 below shows the current share of EU demand met by domestic manufacturing of select clean-energy technologies and components. For several technologies (e.g. solar PV, batteries), European supply strongly depends on imports from third countries, either in the form of final equipment or in the form of indispensable components and raw materials. For others (e.g. onshore and offshore wind), current figures indicate a high degree of self-sufficiency.

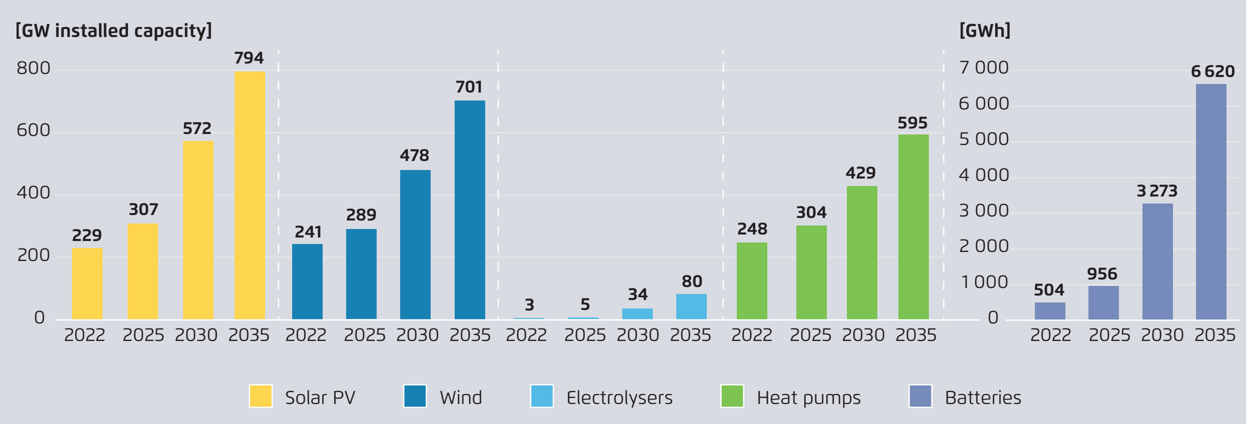
A currently high share of European manufacturing does not mean that the respective industrial value chain is resilient. The EU wind industry, for example, greatly depends on imports of raw materials such as neodymium, praseodymium and dysprosium, which are required to produce permanent magnets in the generators of wind turbines. So despite high levels of EU manufacturing in onshore and offshore wind technologies, there exists a very concerning vulnerability of the overall value chain.

Conversely, low levels of EU manufacturing (e.g. for batteries) do not necessarily imply lack of resilience of the underlying clean-tech value chains if the sources of raw and refined materials or final products

6 Except for batteries, the numbers derive from the scenario modelled for the study Agora Energiewende (2023), "Breaking free from fossil gas" that is in most part compatible with Commission modelling underpinning the Fit for 55 policy package (see overview in Annexes 1–3 of the study). Scenario data on batteries is taken from Roland Berger.

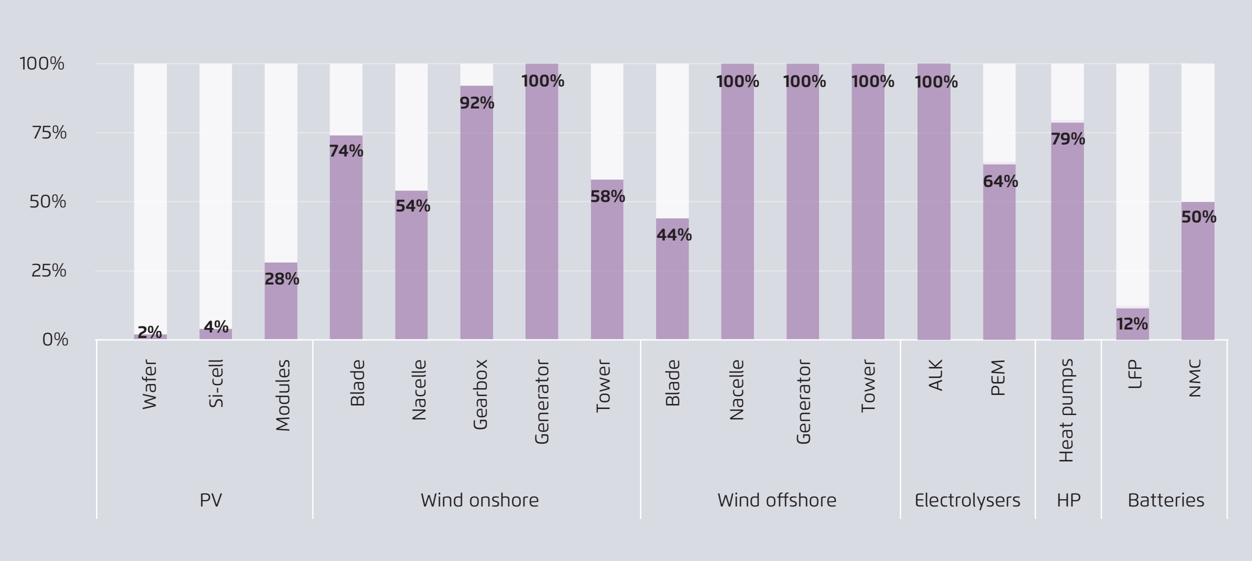
Ramp-up of installed capacity of select clean technologies in EU-27 for transition to climate neutrality

Figure 1



Figures for Solar PV, Wind, Electrolysers and Heat Pumps based on Agora's EU Gas Exit Scenario; for batteries based on data by Roland Berger.

Share of EU demand met by domestic manufacturing, 2023 Figure 2



Roland Berger (2023).

are diversified (or supported by economic partnership agreements) and if high levels of material recycling will gradually replace the need to import refined materials in the future.

These considerations seek to underscore that the **resilience of industrial value chains is the result of several elements**: the respective level of EU manufacturing and domestic supplies, the existence of diverse

Elements adding to the resilience of industrial value chains Figure 3

Agora Energiewende (2023).

international suppliers for critical materials or components and effective policies to advance circular uses or the substitution of materials and components (see figure 3).

Domestic manufacturing: This is only one way – and often not the most economically efficient way[7] – to increase the resilience of industrial value chains. And while a minimum domestic industrial base can serve as an insurance against potential risks of disruption to clean-tech value chains, it will be important to strengthen all aspects of resilience in parallel as part of a broader, multi-year strategy that will take several years to bear fruit.

Mining in Europe: The existence or absence of critical raw materials is due to geological happenstance. In cases where materials are currently not extracted in Europe but can be found in known or likely deposits, one needs to factor in the lead times for starting new mining projects. Recent discoveries, of Europe's to-date largest deposits of rare earth elements in northern Sweden or of high-grade phosphate rock in Norway for instance, are estimated to be sufficient to meet or even exceed the EU's demand of the respective materials. Early geological mappings in Greenland also show a great potential for extracting several critical raw materials, ranging from graphite for battery electrodes to platinum group metals, used in electrolyser technologies and others.[8] They could play a major role in ensuring the scaling up of clean-tech deployment in the future. However, mining in Europe is not a quick fix to reduce current vulnerabilities, as the first commercial extraction of ores from these discoveries may take ten to fifteen years.[9]

International partnerships: International partnerships can enhance resilience through supply diversification. Sourcing supplies from more than one country or region reduces the risk that a clean-tech value chain may be temporarily or even permanently disrupted. Such partnerships will also gain in relevance with the growing number of countries making efforts to transition to climate neutrality, as global demand for clean technologies rises accordingly. Currently, China plays a particularly dominant role in several clean-tech value chains, such as access to raw materials, processing, refining and the manufacturing of components and products (for details, see section 4 below).

Several strategies are conceivable to reduce existing vulnerabilities. The EU could develop or deepen strategic partnerships with countries rich in raw materials. In this regard, it is important to move beyond the logic of bilateral agreements that only focus on lowering barriers to trade and investment, to broader climate neutrality partnership agreements with a broader set of instruments, including on technology cooperation, joint research programmes, innovative financing to de-risk clean investments, or clean energy infrastructure development. Europe could also seek to reduce its current vulnerabilities by "friend-shoring" clean-tech value chains. For example, the EU could support countries in Latin America to advance in the refining of critical raw materials found in the region and perhaps also in clean-tech manufacturing. Finally, Europe could also seek to secure long-term commitments from leading clean-tech producers to manufacture in Europe. One recent example would be the investment of CATL into a battery gigawatt factory close to Erfurt, in the German state of Thüringen.

Circularity: Another source of increasing significance for the growing deployment of clean-energy technologies will be the recycling of materials and components, thereby reducing the need for imports. While common metals found in most equipment, like

7 "The world is in the grip of a manufacturing delusion", The Economist, 13 July 2023.

8 https://eng.geus.dk/about/news/news-archive/2023/june/great-potential-for-critical-raw-materials-in-greenland

9 https://www.politico.eu/article/mining-firm-europes-largest-rare-earths-deposit-found-in-sweden/ ; https://www.euractiv.com/section/energy-environment/news/great-news-eu-hails-discovery-of-massive-phosphate-rock-deposit-in-norway/

copper and aluminium, already feature meaningful end-of-life recycling rates, rare earth elements and other raw materials typically found in batteries and permanent magnets show a large potential for recycling increases. Independently of recycling rates, however, the absolute demand for materials will increase dramatically and sufficient volumes of recycled materials will only play a role in a circular material supply post 2030.[10]

Substitution: Eliminating or drastically reducing the need for critical raw materials can be a very effective way of reducing the risks and vulnerabilities along a value chain. However, this approach must always be weighed with potential losses in economic or technological efficiency. A case in point is the use of permanent magnets in wind turbines. While rare-earth-free wind turbine designs are widely available, the use of rare earths for permanent magnets delivers critical improvements in performance, particularly in the offshore sector. Research and development to reduce the need or even fully substitute rare earth materials is ongoing and highly important, but it is not likely to deliver demand reductions in the short term, considering the overall demand for these materials is projected to grow substantially.[11]

Efforts to increase the resilience of clean-tech industrial value chains will need to be tailored to each value chain. They should start from a robust analysis of the status quo and a mapping of the main risks, expected sector developments and suitable measures for increasing resilience.

To provide a robust basis for such a debate, the following section describes these aspects for five important clean technologies: solar PV, wind (on- and offshore), electrolysers, heat pumps and batteries.

We then seek to identify an appropriate contribution of EU manufacturing for increasing the resilience of the industrial value chains for these technologies, as both the Net Zero Industry Act and the Critical Raw Materials Act proposals mainly focus on measures **within Europe** to strengthen the resilience of value chains of "strategic net-zero technologies" (for overview see Infobox 1).

10 JRC (2023), Supply chain analysis and material demand forecast in strategic technologies and sectors in the EU – A foresight study.

11 JRC (2016) Substitution of critical raw materials in low-carbon technologies: lighting, wind turbines and electric vehicles; Pavel et alii (2017), Substitution strategies for reducing the use of rare earths in wind turbines, Resources Policy (Vol 52, June 2017), pp. 349–357.

Infobox 1: The Net Zero Industry Act and the Critical Raw Materials Act

The proposed **Net Zero Industry Act (NZIA)** of 16 March 2023 aims to scale up European manufacturing capacity of net-zero technologies. It puts forward an overall domestic manufacturing benchmark target of 40 percent of the EU's annual deployment needs of strategic clean-energy technologies by 2030, with indicative technology-specific capacity targets. Provisions to accelerate and streamline the permitting of clean-tech manufacturing projects are complemented by ideas to unlock public funding for strategic net-zero projects, including through public procurement. The NZIA also proposes a target of 50 million tonnes of annual CO_2 storage capacity in Europe by 2030.

The **Critical Raw Materials Act (CRMA)** was proposed in tandem with the Net Zero Industry Act. It addresses the EU's import dependence on critical raw materials along the value chains of strategic net-zero technologies. The CRMA proposes benchmarks for 2030 for intra-European extraction (10%), processing (40%), and recycling levels (15%) relative to EU annual demand for such materials. It further proposes that a maximum of 65 percent of any strategic raw material should be sourced from a single third country to limit overdependencies.

4 Status quo and expected development of clean-tech value chains

Our analysis focuses on five clean energy technologies listed in the annex to the NZIA proposal as strategic net-zero technologies: solar PV, wind (on- and offshore), electrolysers, heat pumps and batteries.[12] A fast deployment of these technologies relies on well-functioning international industrial value chains and access to relevant raw materials.

Each value chain displays a varying set of challenges and starts from a different position in terms of the European manufacturing landscape, value-chain dependencies, market maturity and expected future developments. The main value chain risks from an EU perspective are summarised in Table 1 below.

4.1 Solar PV

Status quo
The solar PV industry may be the most challenging sector in the European clean-energy manufacturing landscape. Europe once boasted a leading PV industry that significantly contributed to technological development and cost reductions in the sector. However, the industry experienced a drastic decline due to growing competition, particularly from Chinese companies. Any effort to ramp up EU manufacturing will thus have to pick up from a very low starting point, especially regarding wafer and cell production.

Globally, the solar PV industry is dominated by China across the entire value chain. Chinese companies vastly surpass the rest of the world's production capacities combined, making the EU highly reliant on Chinese companies as suppliers of solar PV components (89 percent of imports) and raw or processed input materials.

In Europe, the solar PV industry currently features mainly in the module manufacturing segment, with a fairly distributed footprint across the continent and notable clusters in eastern Germany and in Benelux.

Raw materials
The key material in the solar PV value chain is silicon. While the basic input material, quartz sand, is abundant and found across the world, the energy-intensive processing of highly purified silicon, which is needed for wafer production, is largely concentrated in China. Chinese companies produce over 75 percent of global polysilicon supplies, particularly in the Xinjiang region.[13] Notwithstanding China's global dominance in polysilicon production, Europe has a solid manufacturing basis for this processed precursor material, which can cover roughly one-third of current European demand.

Industry trends
Solar PV is today the cheapest source of generating electricity.[14] At global level, the PV industry is therefore projected to experience rapid growth that will likely, for a period, result in overcapacity and thus lower prices. According to the International Energy Agency, announcements for solar PV manufacturing would – if realised – exceed the deployment needs of the IEA's Net Zero 2050 scenario by 2030,[15]

12 The description in this section draws on the comprehensive analysis done by Roland Berger that is available on the Agora Energiewende website. Where relevant, additional references are provided.

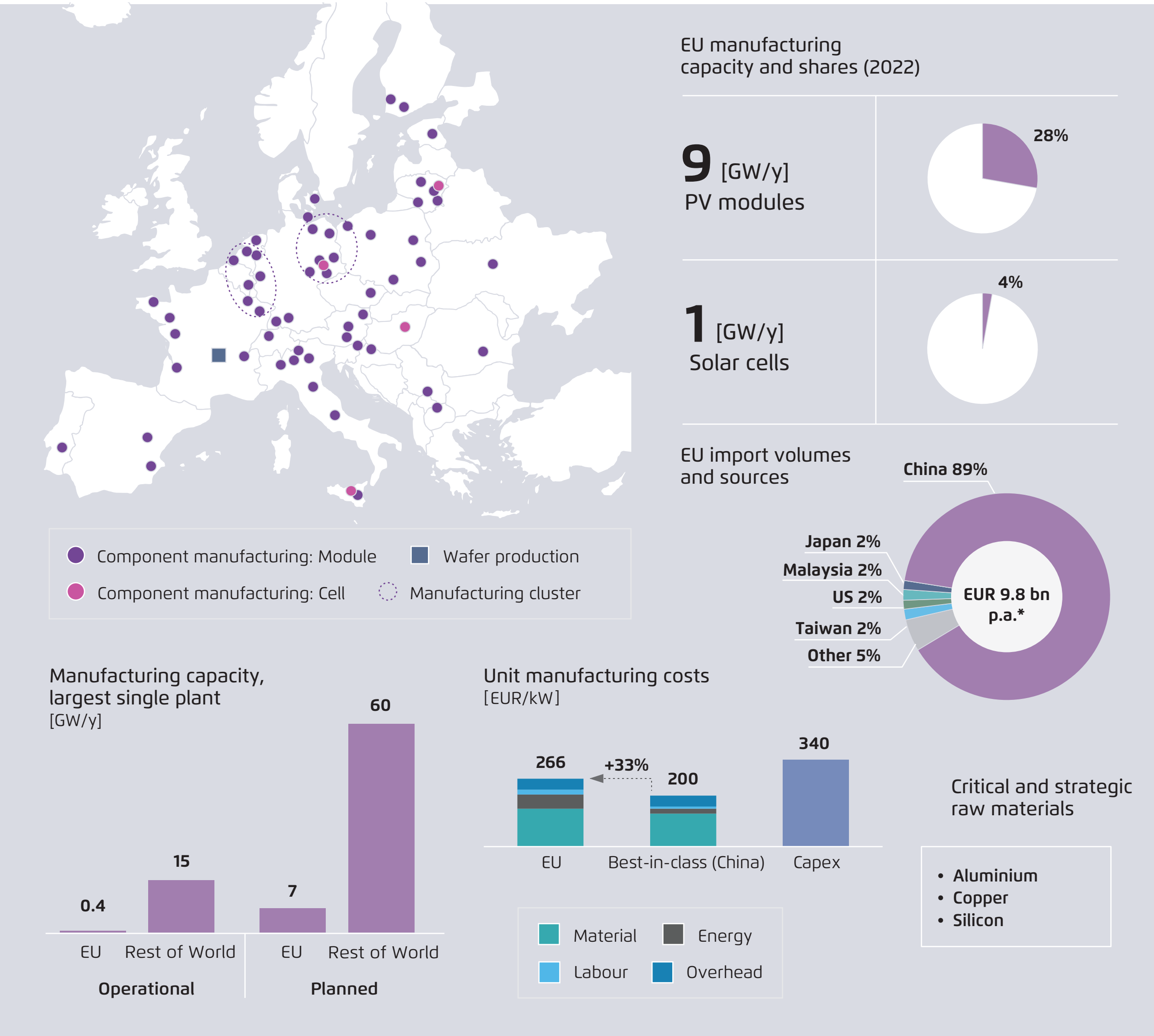
13 Rystad Energy, https://www.reuters.com/breakingviews/supply-chain-scrutiny-may-upend-eu-solar-ambitions-2023-05-23/

14 IEA (2022), Renewables 2022.

15 IEA (2023), The State of Clean Technology Manufacturing.

Photovoltaic: European value chain landscape

Figure 4



Roland Berger (2023). *Rounding errors may occur.

which is excellent news for efforts to contain the climate crisis. However, growth of the sector is highly concentrated in Asia and dominated by China, which alone accounts for 80 percent of capacity additions in 2022.[16]

European solar industry does not feature significantly in these growth projections. Of over 100 GW of announced projects in Europe, around 16 GW seem realistic based on conservative estimates. To put this into perspective: in 2022 China reached manufacturing capacities of roughly 500 GW/y across all key components, with additions in 2023 increasing

16 IEA (2023), The State of Clean Technology Manufacturing.

capacity by around 50 percent to reach an estimated 750 GW of annual production levels.[17]

Competitiveness
Solar PV panels are a commoditised good with production costs highly dependent on economies of scale, labour and energy costs. Manufacturing of solar PV in Europe is at a significant cost disadvantage compared to leading Chinese companies. Unit manufacturing costs in Europe are typically around one-third higher than best-in-class production, as energy costs in Europe are three times and labour costs twice as high as in China, according to Roland Berger. Additionally, the economies of scale reached by Chinese gigafactories with capacities of up to 15 GW/y are currently far out of reach of European competitors, which do not feature any gigafactories as of yet. While announced projects in Europe indicate future annual capacities of up to 7 GW, the growth in the Asian industry is likely to produce facilities with nearly tenfold capacities of those plans.

Main risks and challenges
The dominance of Chinese companies in the solar PV supply chain currently constitutes the highest risks for the rapid deployment of solar PV in Europe. As the recently announced Chinese export control regime for gallium and germanium – materials critical for producing semi-conductors and solar panels – shows, the Chinese government is well aware of the strategic relevance of solar PV and the dominant market position of Chinese companies.[18]

The dominance of Chinese companies also creates challenges in supplier diversification, as the raw material supplies of these companies is typically secured through long-term contracts and inter-governmental partnerships with countries outside of China.

The fast pace of technological advances in the solar PV industry presents both a risk for established industries as well as an opportunity for new competitive technologies and companies. However, it also means that public support measures will not only pick "winners", but also companies that will not remain competitive in the future. Furthermore, given the overcapacities and low prices ahead, public support will need to come with a long-term commitment in order to build a sustainable industry.

4.2 Wind

Status quo
Out of the five sectors analysed in this report, the wind industry currently has the strongest overall position in Europe, although this position is challenged. The wind industry is particularly strong in regional clusters in the northern Iberian Peninsula, in the Benelux states and in Germany and Denmark. For most components, domestic production capacities are currently sufficient to meet annual demand in Europe. The industry is particularly well positioned in the offshore sector, where European companies had a 23 percent global market share in 2022. European imports of wind turbine equipment amount to 0.6 billion euros per year, with roughly two-thirds being sourced from China and one-third from India.

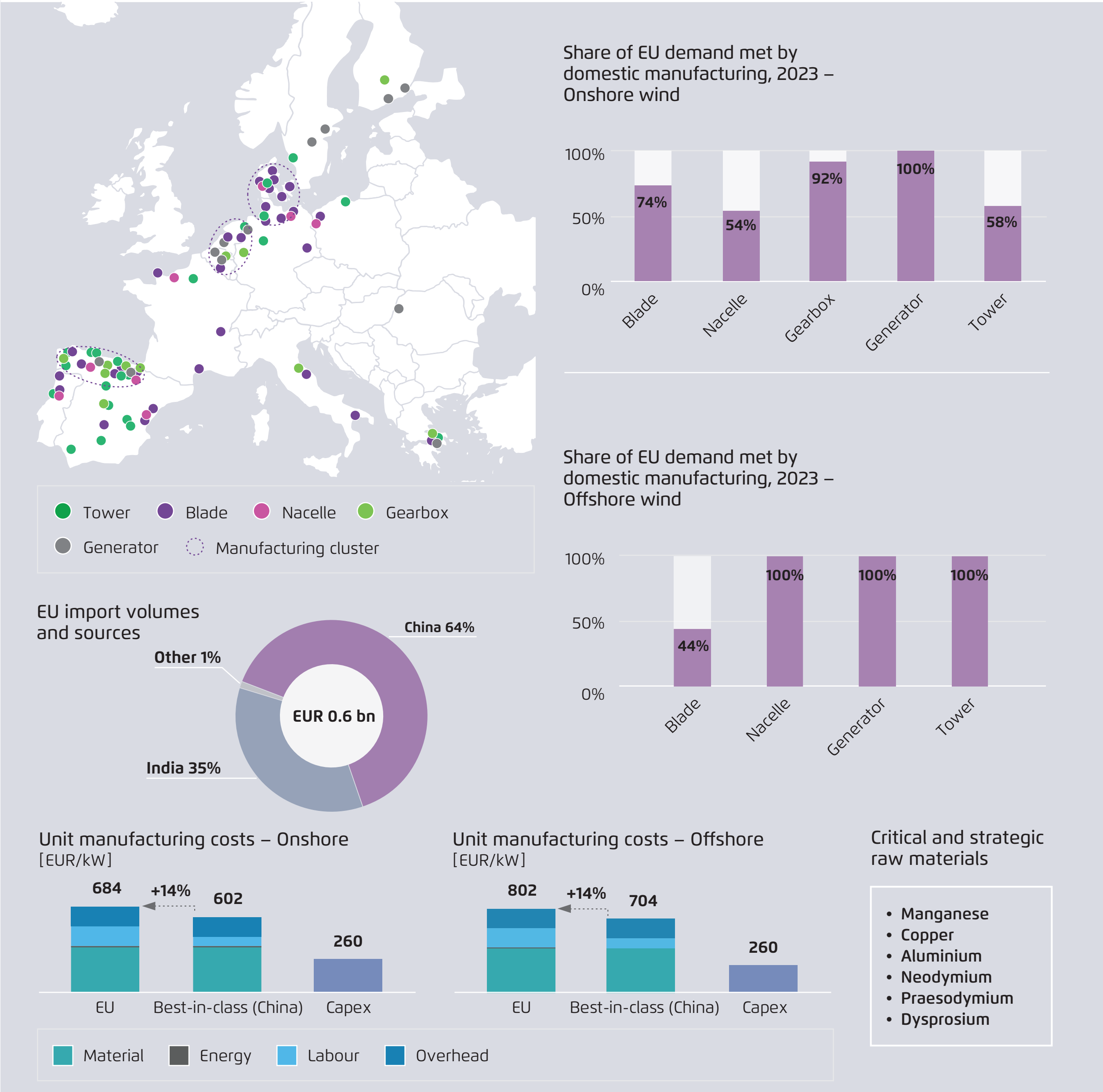
From a resilience perspective, it is important to stress that the European wind industry is highly dependent on foreign suppliers of materials and pre-components further up on the value chain. The industry is also exposed to increasing competition, especially from Chinese companies that can build on strong domestic demand, low prices for steel and for energy and state guarantees for overseas investments. Chinese companies are increasingly outcompeting European suppliers in Latin America, Africa and the

17 IEA Renewable Energy Market Update June 2023, https://www.iea.org/data-and-statistics/charts/solar-pv-manufacturing-capacity-by-component-in-china-2021-2024

18 https://www.politico.eu/article/china-beijing-threaten-curb-mineral-supply-to-west-amid-widening-tech-war/ of 4 July 2023.

Wind: European value chain landscape

Figure 5



Roland Berger (2023). *Rounding errors may occur.

Middle East, and are also starting to get a foothold in European markets, particularly in South and South-eastern Europe.[19]

Raw materials

The bulk of raw material for manufacturing wind turbines is steel, which is not of particular strategic concern in terms of geographical concentration. For the permanent magnets used in the electrical genera-

19 https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/china-s-increasingly-cheap-wind-turbines-could-open-new-markets-72152297

tors on the other hand, the supply of raw materials, such as neodymium, praseodymium and dysprosium, is of very high concern, as the value chains, from raw materials to processing to manufacturing, are highly dominated by Chinese companies (85 percent and 100 percent for neodymium and dysprosium respectively). Only eight manufacturers of permanent magnets are located in Europe, with a current total capacity of only 1 000 tonnes per year. Recent discoveries for example in Norway, including offshore deposits, are found to contain manganese crusts that include neodymium and dysprosium.[20] Exploiting these resources could deliver meaningful volumes in the next decade, but it will not make a short-term contribution to enhancing resilience. With a recovery rate of rare earth from scrap materials of currently less than one percent, there is also a significant potential to increase the circular supply of these critical raw materials in the future.[21]

Industry trends

The European wind industry, particularly the onshore wind segment, faces a challenging outlook. The sector is currently suffering from an overall low profitability and rising market shares of rival companies within Europe. Unless measures are taken, the projection is that the industry will maintain current capacities but will lose ground year-on-year in market share due to the expected rapid increase in demand.

Competitiveness

While Chinese companies maintains cost leadership in production, high shipping costs of bulky wind turbine components limit the competitiveness of imported Chinese equipment in Europe. Production costs in Europe are fairly competitive with the lowest-cost producer (China), with a premium of 14 percent, for both on- and offshore segments. The crucial cost driver making up the difference is the higher labour costs
in Europe.

Main risks and challenges

Considering the dependencies on single suppliers for pre-components, particularly of permanent magnets, the resilience of the European wind manufacturing industry is considered to be at high risk. Decreasing profitability of the sector in Europe and increasing competitiveness of Chinese suppliers puts the sector in a challenging position to maintain market shares or even grow in line with rapidly increasing demand. It also means that potentially scarce manufacturing capacity in Europe, in a rapidly growing world market, will keep costs for the much-needed build-out of wind in Europe high.

4.3 Heat pumps

Status quo

European manufacturing capacity for heat pumps is sufficient to meet roughly 80 percent of current demand in the EU. The manufacturing landscape is centred around Central Europe and relatively spread out into a larger number of smaller-scale production facilities. Sourcing of third-country equipment shows a comparatively diversified picture, with just over 40 percent being imported from a mix of different countries (mostly in Asia) and the remainder coming from China. Most of manufacturing sites produce household-sized heat pumps. There are only a few manufacturing sites that produce large-scale heat pumps, which play an increasingly important role for decarbonising heat grids and lower-temperature industrial processes. Deployment of large-scale heat pumps is projected to rise sharply.[22]

20 https://www.reuters.com/markets/commodities/norway-finds-substantial-mineral-resources-its-seabed-2023-01-27/

21 https://eitrawmaterials.eu/wp-content/uploads/2021/09/ERMA-Action-Plan-2021-A-European-Call-for-Action.pdf

22 Agora Energiewende, Fraunhofer IEG (2023), Roll-out von Großwärmepumpen in Deutschland. Strategien für den Markthochlauf in Wärmenetzen und Industrie.

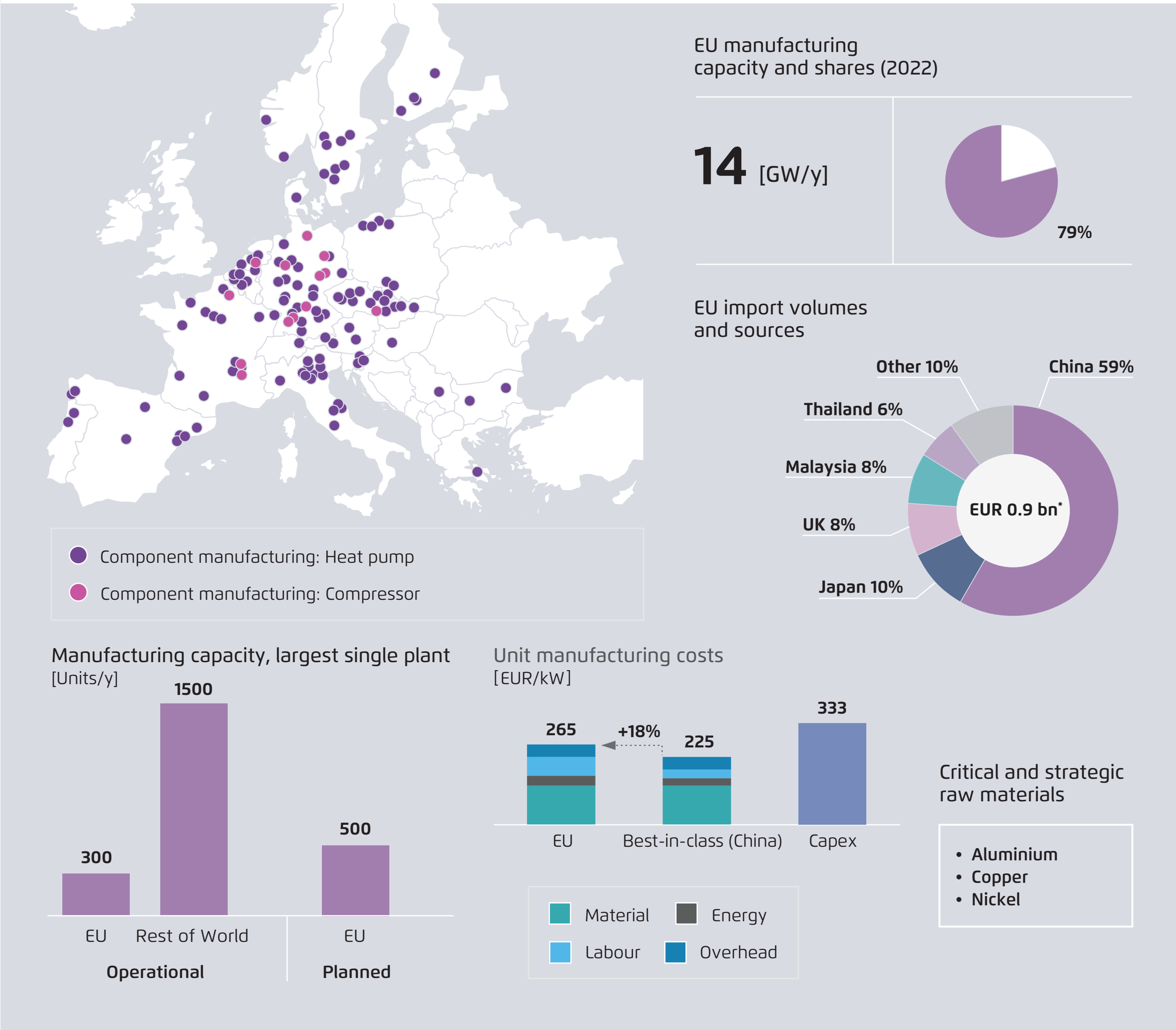
Raw materials
Manufacturing of heat pumps does not require rare earth elements and is thus comparatively less exposed to critical raw material risks.

Industry trends
Industry announcements show plans for capacity additions in Eastern Europe. However, based on a conservative assessment, the trend shows overall capacities remaining stable up to 2030, with an estimated compound annual growth rate of 0.5 percent. The global market development shows increasing shares of Asian manufacturers in Europe. Without further investments, the domestic manufacturing share is projected to fall to 47 percent of annual demand.

Competitiveness
Heat-pump production in Europe has a cost disadvantage compared to lowest-cost producers of around

Heat pumps: European value chain landscape

Figure 6



Roland Berger (2023). *Rounding errors may occur.

18 percent. This is a result of a combination of factors, including more limited economies of scale, less automation and digitisation. The largest facilities in Europe only reach 20 percent of the capacities of leading global competitors. One regulatory opportunity for EU technology leadership is the mandatory replacement of fluorinated gases as refrigerants, which is currently being debated in the update to the EU regulation on fluorinated greenhouse gases.[23] European heat pump manufacturers currently also benefit from a close working relationship with retailers and installers and an established level of trust with customers that would prove difficult to regain should the market be dominated by Asian manufacturers.

Main risks and challenges

The current situation of the European heat-pump manufacturing landscape combined with a lack of exposure to critical raw material risks suggest a cautiously positive outlook for the sector if current competitiveness issues are addressed. The most important concern is the potential delay in legislative commitments to phase out stand-alone fossil boilers for heating homes, which could see heat-pump demand well below what would be needed from a climate-neutrality perspective. Other concerns are missing public awareness about the advantages of heat pumps and a skills gap in heat-pump installations.

4.4 Electrolysers

Status quo

The electrolyser market is at a nascent stage, with few large-scale manufacturing sites. However, the European industry is well situated, with current production capacities of ~2 GW/y, surpassing currently low demand and installed electrolyser capacity in the EU, and significant manufacturing capacity additions are expected. European manufacturers are targeting both alkaline and Proton Exchange Membrane (PEM) electrolyser segments, while also developing innovative electrolyser technologies such as solid-oxide electrolysis and anion exchange membrane electrolysis.

Industry trends

The electrolyser industry is currently gearing up to serve the significant growth in projected demand in Europe and worldwide, with numerous announcements for capacity expansions of electrolyser manufacturing. However, given currently higher costs of renewable hydrogen compared to fossil alternatives, investments into electrolyser production in Europe require a robust, long-term support framework for renewable hydrogen demand. Relatively few final investment decisions for deploying electrolysers in Europe, combined with the foreseen effects of the US Inflation Reduction Act, are a signal of market uncertainty. The current market outlook is thus rather conservative.

Raw materials

Electrolysers rely on a number of critical and strategic raw materials, where Europe is fully reliant on imports. Aside from copper and aluminium, which is employed in both technologies, the alkaline electrolysis segment is reliant on imported nickel, zirconium and graphite for the electrodes. The Proton Exchange Membrane (PEM) technology on the other hand requires platinum group metals, the supply of which is highly concentrated in South Africa. However, innovation could reduce or even eliminate the need for these metals.

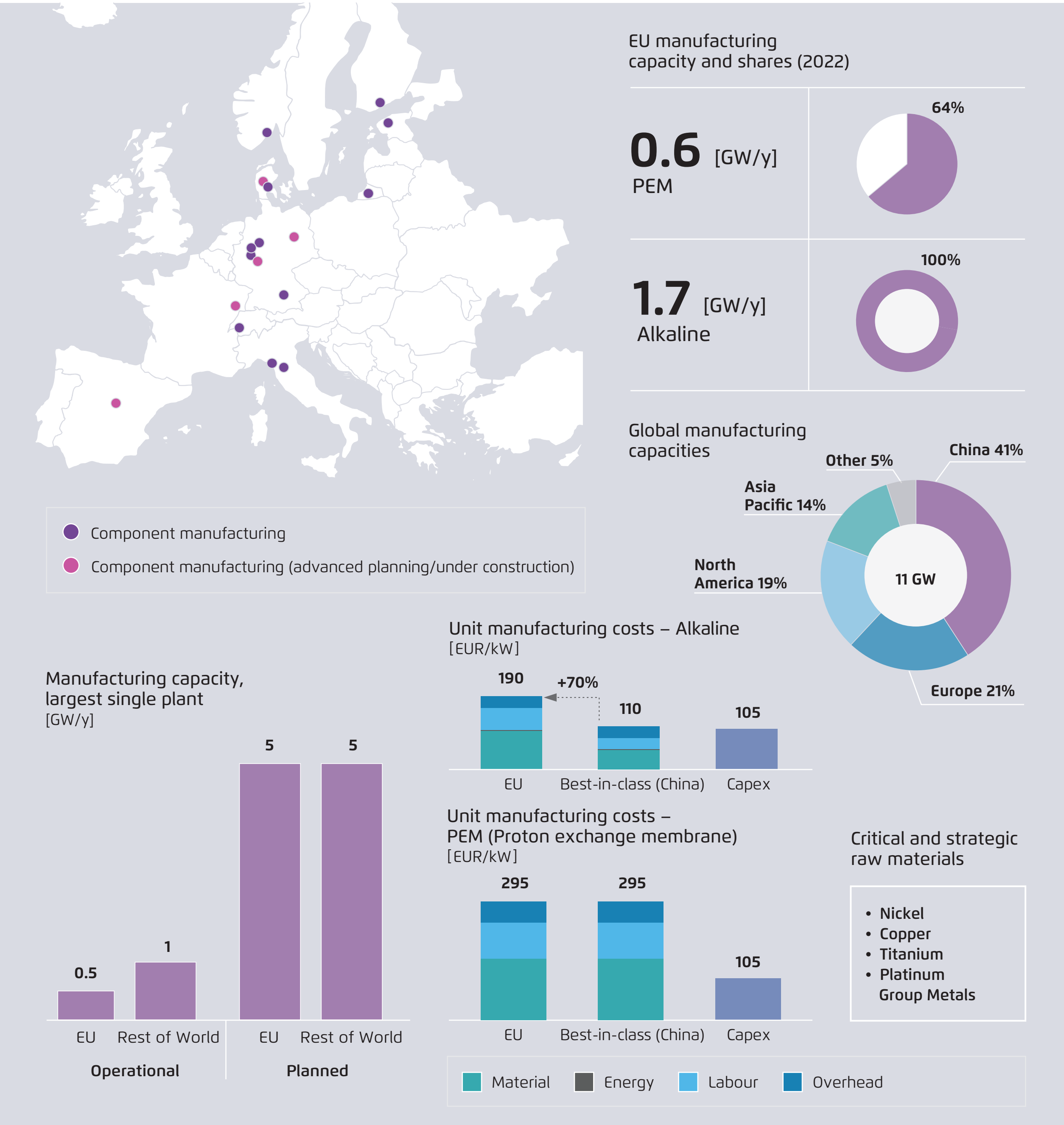
Competitiveness

The European industry is especially advanced in the PEM segment, where it retains a technological advantage, while Chinese manufacturers have a clear cost advantage in the alkaline electrolysis segment. With production of alkaline electrolysers in Europe over 70 percent more costly than best-in-class costs in China, European industry is at high risk of losing market share.

23 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022PC0150

Electrolysers: European value chain landscape

Figure 7



Roland Berger (2023).

Main risks and challenges
The electrolyser industry is at the early stages of development. Risks result from uncertainty in the market about how realistic high hydrogen-demand targets really are. Generous tax breaks for (renewable) hydrogen production under the US Inflation Reduction Act are currently diverting investments into new production facilities away from Europe. Supplier concentration of critical raw materials presents a challenge, although R&D efforts will foreseeably

reduce the needs for some critical materials (e.g. platinum group metals).

4.5 Batteries

Status quo

Europe currently features a limited number of battery manufacturing sites. Their total capacity, however, is sufficient to meet a significant share of the EU's demand. The European battery industry is more developed in the Lithium Nickel Manganese Cobalt Oxide (NMC) battery technology, which currently is the predominant technology for batteries used in electric vehicles. In this segment, EU production is sufficient to meet 50 percent of the EU's current annual demand. In the other main technology segment, Lithium Iron Phosphate (LFP), the manufacturing landscape is less developed; manufacturing capacity meets only 12 percent of annual demand.

In terms of absolute production capacities, European battery manufacturing lags far behind the global leader, China. However, considering economies of scale, the largest plants in European are in the same range as global leaders, with annual capacities of up to 35 GWh/y compared to 60 GWh/y in China, and concrete plans exist for European gigafactories with individual capacities reaching over 100 GWh/y.

Industry trends

Planned capacity additions indicate a significant growth in the European battery manufacturing sector, particularly in the NMC segment. The NMC segment is expected to double in volume deployment, while the LFP sector is projected to grow by a factor of six (albeit from a lower level), a conservative estimate on project materialisation considering existing final investment decisions.

Raw materials

Battery chemistries require a range of rare earth elements and critical raw materials that are not extracted within the EU, resulting in significant import dependencies of raw and processed raw materials. For both NMC and LFP batteries, graphite and lithium are essential. These are predominantly sourced from China and Chile. NMC batteries further require nickel, manganese and cobalt. The extraction of cobalt and nickel is geographically concentrated in countries, such as the Democratic Republic of Congo and Indonesia respectively, with frequently reported violations of international labour or environmental standards. Technological developments are steadily reducing the intensity of cobalt in battery chemistries; however, this shift is mostly occurring at the expense of higher nickel intensities.[24] LFP batteries completely do away with the need for cobalt, nickel and manganese and instead rely on phosphate, which can be found in Europe, not least in a massive new deposit discovery in southwest Norway.[25]

Competitiveness

European industry is at a significant comparative disadvantage, with almost 50 percent higher unit manufacturing costs compared to best-in-class producers in South Korea and China. This cost gap is largely determined by material costs, which are considerably lower in Asia due to more advanced supply chains in terms of vertical integration of material supply, processing and manufacturing.

Main risks and challenges

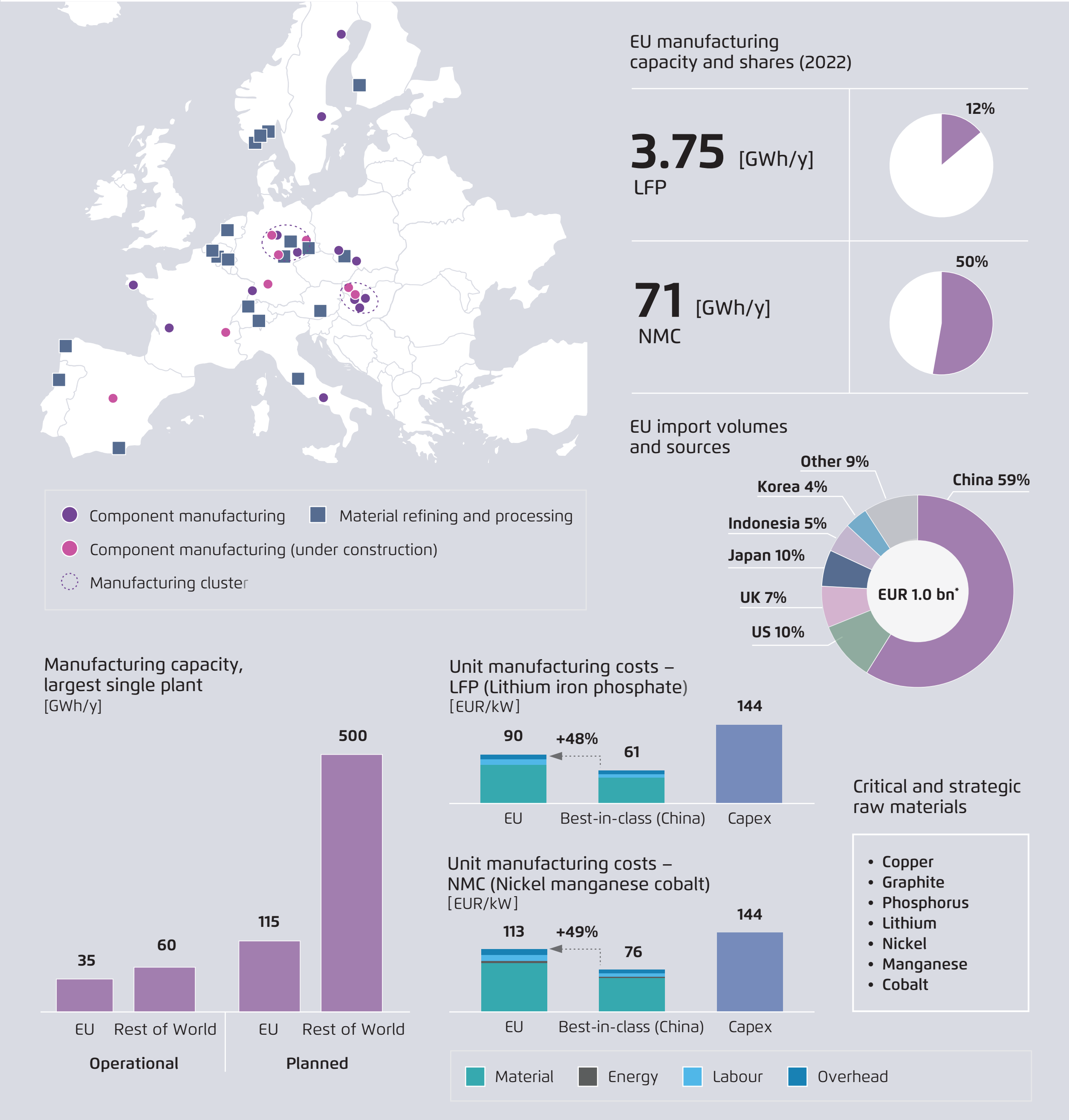
The production of batteries is highly reliant on a number of critical raw materials with strong geographic concentrations both for extraction and processing. The main risks are therefore related to the sourcing of critical raw materials and the limited processing levels in Europe.

24 https://think.ing.com/articles/tightening-supply-shakes-up-battery-metals/

25 https://theconversation.com/huge-phosphate-discovery-in-norway-could-fully-charge-the-electric-vehicle-industry-209189

Batteries: European value chain landscape

Figure 8



Roland Berger (2023). *Rounding errors may occur.

The current technological leadership and market dominance of Asian companies present further challenges for developing battery manufacturing in Europe.

Main clean-tech value chain risks from EU perspective — Table 1

Solar PV	Wind (on-/offshore)	Electrolysers	Heat pumps	Batteries
Market dominance of China along the entire supply chain, low starting point in EU Limited production of pre-components Profitability and competitiveness of production	Profitability of the sector Single supplier dependence on critical raw materials and components (permanent magnets) Increasing competition from China	Market uncertainty Production competitiveness in the established alkaline sector Reliance on critical raw materials with limited sources	Installation bottlenecks Market and demand uncertainty given volatile regulatory environment Low economies of scale compared to competitors	Sourcing of raw and processed input materials Market dominance of Asian industry leaders

Agora Energiewende (2023).

5 Minimum shares of EU clean-tech manufacturing as contribution to value chain resilience

As explained above (section 3), EU manufacturing is just one lever for strengthening the resilience of clean-tech value chains. Other important levers are supply diversification (through opening domestic mining activities, developing strategic partnerships with resource-rich countries, 'friend-shoring' of clean-tech production, etc) and the expansion of circularity policies, as well as R&D on substituting critical materials needed for producing clean technologies (e.g. replacing cobalt as the cathode material in NMC batteries).

However, considering the focus of policy debates on the NZIA and the CRMA, the main focus of our analysis is on identifying appropriate minimum shares of EU manufacturing as a contribution to enhancing the resilience of Europe's clean energy transition.

The methodology, developed by Roland Berger to this end, builds on the value-chain analysis of the five clean technologies described above. It identifies and quantifies for each step in the different value chains existing economical, geopolitical, technological, geographic and digital risks. On this basis, it develops an overall risk score, which then allows the calculation of minimum shares of EU manufacturing per technology or subcomponent.

Risks considered include the extent to which supply chains are dependent on a single supplier at any given stage, the likelihood of a disruptive event affecting a supply chain and the exposure to environmental and social risks. The methodology also captures uncertainties from rapidly evolving technological developments. To give some examples: wafers in the solar PV supply chain are rated with a high-risk score in terms of supplier dependence, whereas their material risks are rated low. Due to the high supply dependency on China, supply-chain risks also receive the highest rating for potential transport and trade disruptions. Supply chains for heat pumps, in contrast, have a low supplier dependency and also feature low raw-material risks. In the battery supply chain, demand for critical raw materials such as cobalt is considered to have a high environmental risk score. The methodology is further explained in Annex 1.

The resulting EU manufacturing shares for each technology – and where applicable also subcomponents – are shown in figure 9 below.

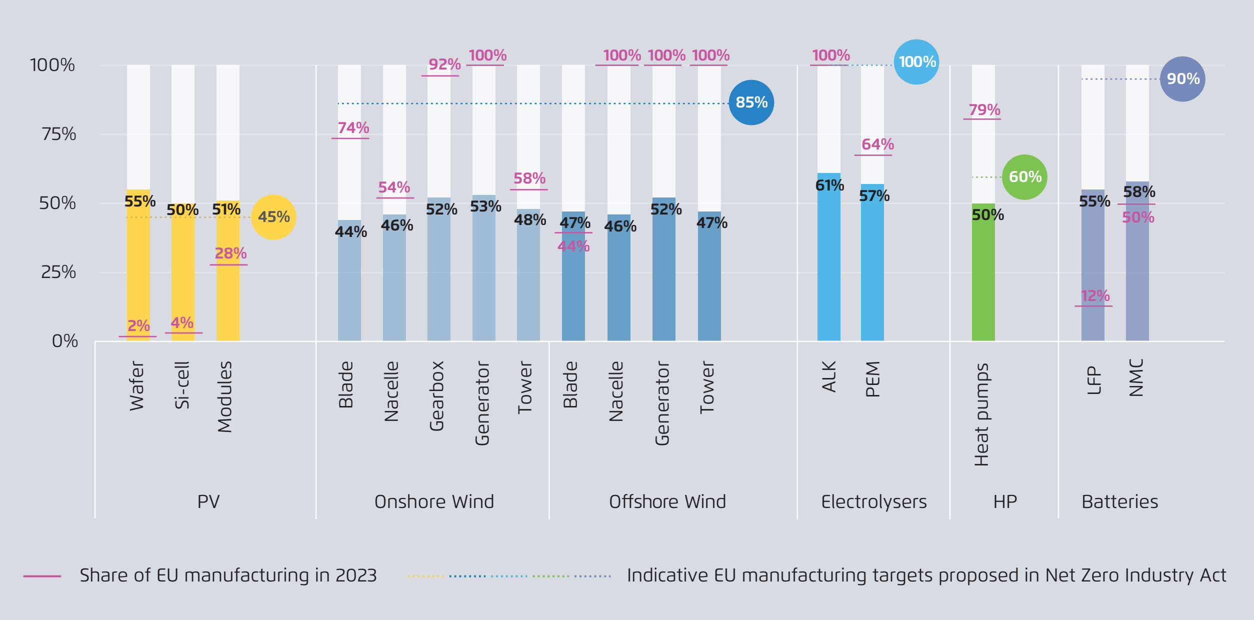
The columns show the calculated minimum shares of domestic manufacturing based on the methodology developed by Roland Berger. The red line in each column indicates the current EU manufacturing shares for the different elements in the different supply chains. Another line shows the indicative EU manufacturing shares included in the proposed Net Zero Industry Act.

Some observations:

→ The minimum shares in figure 9 are based on an overall risk calculation that enables a comparison across value chains. However, since industrial value chains are only as resilient as their most vulnerable element, this calculation needs to be enriched with information on particularly critical risks that could disrupt an entire chain. For example, the wind industry value chain is currently highly dependent on the supply of permanent magnets, which require rare elements as input, for which Chinese companies have a dominant market position both for raw materials extraction and for refining. Despite the fact that current production levels in Europe are well above

Recommended minimum shares of EU demand met by domestic manufacturing

Figure 9



Minimum manufacturing shares and 2023 EU manufacturing shares taken from Roland Berger (2023); Indicative targets taken from Commission proposal for a Net Zero Industry Act.

"resilient" production levels, the analysis by Roland Berger would recommend targeted efforts to reduce the critical dependence of European manufacturers as regards permanent magnets. In this report, we therefore highlight critical dependencies and the potential for diversification or substitution, as in the above description of the five clean technologies, and also reflect on the same aspects in the discussion below on suitable policy measures.

→ Most of the appropriate minimum shares of EU manufacturing calculated by Roland Berger are significantly below the indicative targets in the Net Zero Industry Act. For batteries, the NZIA target is 35 percentage points higher, for electrolysers it is about 40 percentage points higher and for onshore and offshore wind it is around 30 percentage points higher. For heat pumps the difference is only 10 percentage points. The notable exception is solar PV, where appropriate minimum shares for the production of wafers, silicium-cells and modules are 5–10 percentage points higher than the 45 percent indicative target of the NZIA.

→ These differences do not seem to reflect different understandings of the vulnerability of clean-tech value chains, but rather a different methodological approach to identifying desirable shares of EU manufacturing. Whereas the Roland Berger methodology is based on an assessment of risks across the clean value chains analysed, the indicative targets in the NZIA are primarily based on work within EU industrial alliances, and as such reflect industry-led objectives.[26] This also suggests that the indicative targets in the NZIA reflect classic industrial policy objectives (e.g. technology leadership, securing market shares and industrial jobs) as well as objectives to strengthen the resilience of Europe's clean energy transition.

26 See recital 17 NZIA and Commission Staff Working Document SWD(2023) 219 final of 19.6.2023, page 33 ff.

The minimum EU manufacturing shares resulting from Roland Berger's analysis thus indicate the insurance Europe needs to contain the risk that its transition to a net-zero economy will be delayed or derailed.

Achieving such minimum insurance levels presents a formidable challenge for the European solar PV industry as well as the EU batteries industry and will require a significant, long-term policy commitment to supporting the manufacturing of these technologies in Europe, which in the case of solar PV means starting from almost zero today.

There are also good arguments for defending current technology leadership and EU manufacturing levels well above of what is recommendable from an "insurance" perspective. This is particularly the case for the European wind industry, which is still a technology leader in some market segments (see above) but where lack of public support may result in a rapid erosion of Europe's currently strong manufacturing base.

6 The cost of increasing EU manufacturing to strengthen value chain resilience

The EU's transition to climate neutrality requires very significant investments every year into the deployment of clean technology to progressively eliminate carbon pollution from the power system, from industrial activities, from heating homes and from transport. The need to rapidly scale the deployment of clean technologies such as solar PV, wind, heat pumps, electrolysers and batteries is the direct consequence of Europe's commitment to reduce greenhouse gas emissions by at least 55 percent by 2030 and to achieve climate neutrality continent-wide by latest 2050.

Several analyses identify the resulting overall investment needs (private and public) as well as the amount of public funding needed to support or incentivize necessary private investments.[27] And while overall public funding needs to support Europe's transition to climate neutrality are small compared to EU GDP (approximately 1 percent, excluding transport infrastructures), they constitute a significant and indeed growing share of current and future EU and national budgets.

Public funding needed to support the scaling of clean-tech manufacturing in Europe is significantly smaller than public funding needed to support the deployment of clean technologies. However, such funding will need to come on top of the public funding needed for Europe's transition to climate neutrality.[28] Or to put it differently, following the US's IRA example and supporting EU-based manufacturing that has production costs well above best-in-class levels elsewhere will make Europe's transition to climate neutrality more costly overall.

There are good public policy reasons for this, including energy security considerations, insuring Europe's transition against foreseeable risks and broader considerations on industrial policy. However, the starting point is important. **If the scaling of clean-tech manufacturing in Europe would be at the expense of public funding available for supporting the deployment of clean technologies in line with Europe's pathway to climate neutrality, a "green industrial policy" would undermine rather than support the EU Green Deal.**

To support the policy debate on appropriate levels of EU clean-tech manufacturing and also give a sense of affordability and prioritisation from a fiscal policy perspective, Roland Berger used the different levels of EU clean-tech manufacturing described in the previous section to calculate the respective additional costs for required investments and manufacturing.

A **baseline scenario** for each technology reflects the current manufacturing basis with growth based on a conservative projection of project announcements, which are rated according to their realisation likelihood. Considering the significant growth in demand for clean-tech deployment over the next decade, and the low starting point in some sectors, this baseline shows overall decreasing shares of intra-European manufacturing relative to EU demand. Increasing EU manufacturing levels beyond the baseline will come at additional costs for investments and for manufacturing.

The additional costs above the baseline are calculated for a "NZIA scenario" representing the indicative Net

27 See the EU Climate Funding Tracker available on the Agora Energiewende website.

28 See section 9 below.

Zero Industry Act targets and for two "resilience scenarios".

The **NZIA scenario** calculates the additional costs for reaching domestic manufacturing thresholds included in the NZIA proposal and the accompanying Staff Working Document by the European Commission.[29]

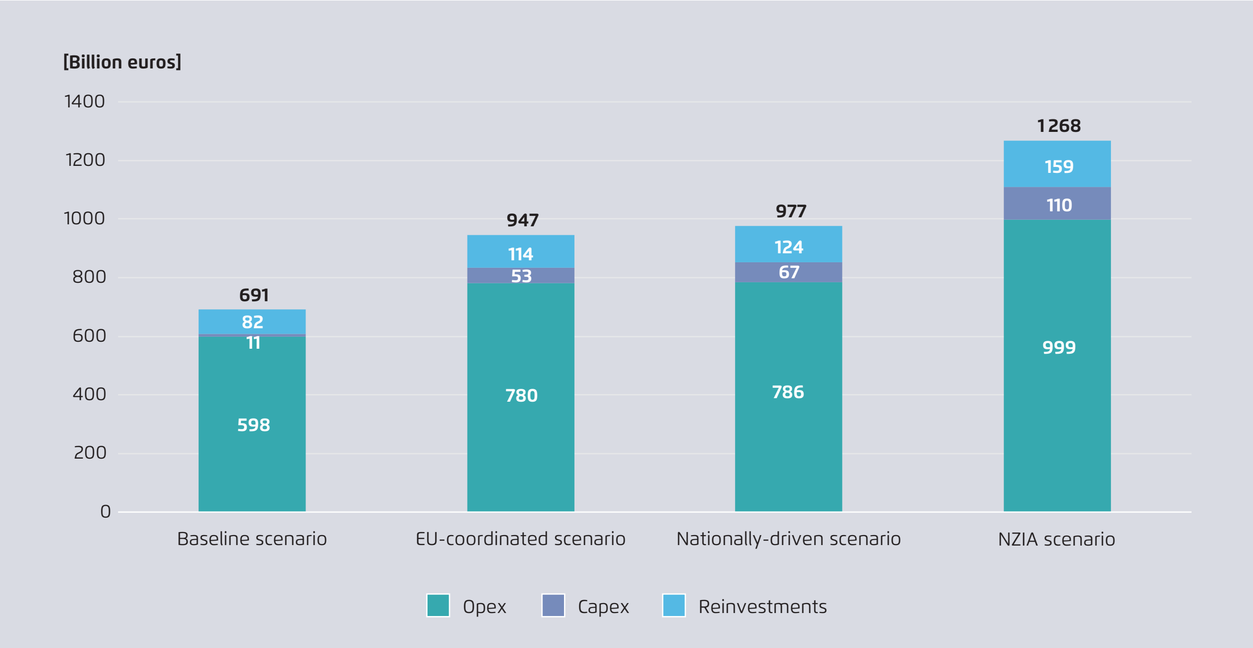
The "resilience scenarios" seek to quantify differences between two principled approaches to achieving resilience: an **EU-coordinated resilience** approach and a **nationally driven resilience** approach. Each scenario calculates additional costs to achieve an EU manufacturing base that meets the minimum market shares derived from the risk assessment analysis described above. The scenarios differ in how this is achieved.

29 COM(2023) 161 final of 16.3.2023 and Commission Staff Working Document SWD(2023) 219 final of 19.6.2023

→ In the **EU-coordinated resilience scenario**, investment into new plants first goes to the most cost-competitive locations in Europe that offer the lowest costs for energy and labour and the best infrastructure and business environments. Prioritising cost-competitive investments will require high EU-level coordination and common financing of the manufacturing investment, with support to Member States most in need.

→ The **nationally driven resilience scenario** considers the opposite case of dominant national policies which are only loosely coordinated. Investment decisions are driven by funding offered by the Member States, which primarily differs according to national ambition and fiscal capacity. This results in more scattered manufacturing investment overall and relatively higher concentration of capacity in the fiscally strongest Member States. The nationally driven scenario is also characterized by higher EU-wide costs for opex and capex, as investments are not concentrated in the most

Total cumulative costs, 2023–2035 — Discounted cash flow | Figure 10



Agora Energiewende (2023) based on Roland Berger data.

productive locations, and a more limited role of EU-level funding.

Figure 10 shows the total cumulated costs (discounted values) to achieve the targeted manufacturing levels in each scenario, over the period 2023–2035.[30]

Several observations can be drawn from these scenarios:

- → Total costs, including both capital and operating manufacturing expenditures, are increasing with the level of ambition in reshoring clean-tech supply chains into Europe. This leads to a significant difference between the resilience scenarios developed by Roland Berger and calculated total costs for achieving indicative targets under the Net Zero Industry Act.
- → *Operational expenditures* make up a significant share of total costs across all scenarios (~70%) compared to capital expenditures and reinvestments (~30%). This has consequences for suitable support measures (for details, see section 7 below).
- → The *NZIA scenario* has the overall highest cumulated costs, as larger manufacturing capacity is built in the EU and there are higher levels of domestic production as a result. The cumulative and discounted amount of investment needs over 2023–2035 to build up new manufacturing capacity is 110 billion euros and the required reinvestments over the same period total 159 billion euros. Reinvestment into operating plants grows sharply at the end of the current decade and dominate the capex needs in the 2030s.[31] Opex nevertheless is the largest share of total costs. Besides material costs, energy expenditures are a key factor in the solar PV supply chain, whereas labour costs are more important in the other clean-tech industries. In the *NZIA scenario*, costs for opex support are around 400 billion euros above the baseline case. Some of these expenses are simply the result of having higher domestic production levels, replacing costs of imports in the baseline scenario. However, the higher opex costs also capture higher unit manufacturing costs of domestic suppliers compared to costs of imported goods.
- → The *resilience scenarios* come with lower overall costs compared to the NZIA target scenario, as the minimum EU manufacturing shares resulting from the analysis by Roland Berger are in part significantly below the indicative technology specific targets included in the NZIA. With total cumulative costs of 947 billion euros (EU-coordinated resilience) and 977 billion euros (nationally driven resilience) over 2023–2035, the additional costs over the baseline are 56 or 50 percent lower respectively than in the NZIA scenario. While the resilience scenarios developed by Roland Berger would ensure similar levels of domestic manufacturing for solar PV and for heat pumps compared to the NZIA scenario, the bulk of the difference in costs comes from less investment into the scaling of batteries manufacturing.
- → When comparing the resilience scenarios to the baseline scenario, it is noteworthy that 21 percent of the cost difference would be from solar PV and 71 percent from scaling batteries manufacturing to the calculated minimum shares. Additional costs for scaling wind, electrolysers and heat pumps would be much smaller.
- → The analysis shows a high price tag for manufacturing batteries in Europe at the level proposed in the NZIA. The resilience scenarios developed by Roland Berger that primarily focus on "risk insurance" against value-chain disruptions would incur significantly lower additional costs above the baseline (up to 204 billion euros for the nationally driven scenario versus 433 billion euros for the NZIA).

30 Annex3 shows the underlying data with total costs by technology and scenario as a difference relative to the baseline, as well as the distribution of costs over the 2022–2035 period.

31 Also see figures 11, 12 and 13 below that provide further detail on temporal and geographic distribution of public funding required.

- Regarding wind turbines, it is important to underline that the calculated cost difference between the indicative targets in the NZIA and the resilience scenarios developed by Roland Berger is relatively small (up to 8.8 billion euros). It would incur much larger additional costs for scaling battery manufacturing in Europe to achieve levels beyond those required from an insurance perspective. So there is a good case for supporting the European wind industry in defending or even expanding its current market shares.
- As regards electrolysers, the resilience scenarios by Roland Berger are slightly less costly than costs expected under the NZIA. The difference owes itself to the lower short-term demand for electrolysers in the underlying Agora scenario compared to the optimistic political target of 10 Mt domestic renewable hydrogen production by 2030 in the REPowerEU plan.[32]
- Finally, the resilience scenarios show that joint EU action will reduce overall costs and the need for public support. The EU-coordinated scenario would lead to a more cost-effective allocation of manufacturing investment across Europe and save 12 percent in overall costs for all technologies compared to the scenario primarily driven by national policies. This difference will likely be larger in reality since the underlying cost calculation of Roland Berger is based on a linear extrapolation that does not reduce additional unit of manufacturing costs for larger-sized projects to reflect economies of scale. So the benefits of EU-coordinated support for giga-scale projects, comparable to investments happening in China or the US, do not become visible. Nevertheless, the cost difference between the two resilience scenarios supports the case for EU-coordinated support on very large investments, adding to considerations of political benefits, both from a fairness perspective and to ease concerns that different fiscal capabilities could drive countries in Europe apart.

32 See Agora Energiewende (2023), Breaking Free from Fossil Gas, pp. 40ff.

7 Measures to compensate for the cost disadvantage of EU clean-tech manufacturers and related public funding requirements

Increasing investments into clean-tech manufacturing in Europe requires measures that compensate for the significant cost disadvantage of EU manufacturers

The dominance of non-EU manufacturers in clean-tech value chains is largely due to their cost competitiveness. In solar PV manufacturing, foreign companies dominate the supply chains because they are able to produce high-quality products at much lower costs.[33] The competitiveness gap in large-scale production comes from higher energy and labour costs in Europe, but also the lack of sufficient economies of scale. The median size of a solar PV cell plant in China, for example, is double that of those in the EU.[34] According to Roland Berger's analysis, international manufacturers also have large cost advantages relative to EU-made batteries (46%) and electrolysers (up to 76 percent for alkaline water electrolysers).

Expanding EU domestic manufacturing capacity in sectors like solar PV and batteries, beyond the level the market would deliver without interventions, will come at a cost to EU consumers and taxpayers. Exposed to international competition, companies will be reluctant to invest in additional EU production capacity unless there is a robust policy framework that reduces demand uncertainty and fixes the cost disadvantage of European plants. Even in markets where the EU is a global leader, like wind turbines, government support can help to protect the market share of local manufacturers in rapidly growing EU and international markets. In short, improving framework conditions for investments in Europe, like easing permitting and removing red tape, is important and possible without weakening rights of public participation or environmental protection standards. However, it will not be sufficient to substitute for measures that address the structural cost disadvantages and profitability issues of clean-tech manufacturing in Europe.

Different policy measures come with different public funding needs

Table 2 below shows different policy options available to shield domestic producers from more cost-competitive producers outside of Europe. Core measures are local content requirements, import tariffs, opex subsidies, capex grants and public procurement.

Local content requirements and import tariffs may seem more attractive from a public funding perspective, as additional costs for manufacturing in Europe would fall on the buyers of clean-tech in Europe. However, these measures also come with very significant political and economic risks.

→ **Import tariffs on foreign products** reduce the cost advantage of non-EU competitors in the EU market and create a business case for (new) production plants in Europe, which would otherwise be unprofitable. Import tariffs take different forms, ranging from anti-dumping measures to carbon pricing on the embodied emissions in imported equipment and materials.[35]

33 Helveston et al. (2022) and Roland Berger's analysis.

34 Analysis based on BloombergNEF data for operating plants.

35 On the latter, McKinsey has analysed the contribution of carbon tariffs in closing the cost gap of EU solar PV manufacturers. See: https://www.mckinsey.com/industries/

→ **Local content requirements** would require clean-tech firms to use a minimum share of domestically manufactured goods or domestically supplied services in order to operate in Europe. Investing in clean-tech manufacturing in Europe would thereby become a precondition for accessing the EU Single Market.

In both cases, additional costs would be borne by European clean-technology adopters, mostly private, unless governments intervene with demand subsidies to absorb part of the cost increase. Higher costs of clean technologies in Europe would make the abatement of greenhouse gases relatively more expensive and could slow climate action. This effect can be mitigated in the case of import tariffs if tariff revenues are used to support technology deployment. There is also evidence that local content requirements can undermine long-term competitiveness.[36] Furthermore, both measures risk international trade conflicts that would likely include costly, retaliatory measures of trading partners (e.g. trade disruption, loss of export opportunities).[37]

The alternative measures (opex subsidies, capex grants, public procurement) come with a lower burden and lower risks for the economy and international trade relations, but with a larger burden on public budgets.

→ **Capex grants** have been the standard instrument at EU level for clean-tech manufacturing support. Support is given for brownfield and greenfield[38] investments and it has an indirect effect on the competitiveness of a plant by reducing the amortisation costs and the cost of capital. High electricity prices weigh on a plant's competitiveness, but if the upfront construction costs are high, they will have an effect too. The one-off nature of this measure makes it more attractive for policy-makers compared to opex support, as it reduces the administrative costs of recurrent support, avoids the overlap of funding outlays between budget periods and is arguably less distortive to the EU Single Market. However, relying only on upfront grants creates the risk of over-subsidisation. The supported manufacturing plant could turn into an unprofitable business and end operations despite the funding received. Or market conditions could turn more favourable than expected, therefore making the initial grant excessive.

→ **Opex support** is a basic precondition for attracting clean-tech manufacturing investment in Europe, in sectors where non-EU production is up to 40 percent cheaper. There are various ways of supporting opex in sectors affected by structural cost disadvantages. Beyond IRA-style production tax credits, support can be handed out through contracts for difference. Whereas the former offers a fixed premium for each production unit, the latter offers a variable compensation equal to the difference between a predetermined value and the market price of the product. Both instruments can be awarded through competitive auctions as a cost-discovery mechanism on firms bidding for support.[39] There is broad agreement in Europe that opex support should be a primary channel for supporting the reshoring process,[40] a message also clearly coming out of the analysis by Roland Berger.

electric-power-and-natural-gas/our-insights/building-a-competitive-solar-pv-supply-chain-in-europe.

36 https://www.oecd.org/trade/topics/local-content-requirements/

37 "China threatens to curb mineral supply to West amid widening tech war", Politico 4 July 2023.

38 "brownfield" refers to additional investments to upgrade, expand or modify existing sites, often with the benefit of reduced permitting needs; "greenfield" to investments at new sites, developing a project from scratch.

39 See for instance the proposed EU Hydrogen Bank (COM(2023) 156 of 16.2.2023) or Pellerin-Carlin (2023), Think house, not brick: Building an EU Cleantech Investment Plan to match the US Inflation Reduction Act.

40 See for instance Pellerin-Carlin (2023); Deloitte and Stiftung Klimawirtschaft (2023), IRA and the net-zero race: How the EU industrial policy should respond.

→ The public sector can also give preferential support to EU manufacturers through technical specifications in its **procurement activities**, paying a premium on what is offered by international suppliers. The public sector is a large consumer of heating appliances, vehicles, construction material and electricity. Requirements would affect not only the downstream firms offering goods and services but also to the upstream supply chains that contributed to the final product or service.

Soft loans and guarantees have lower fiscal costs than direct support but are less effective. They reduce the cost of capital and improve access to credit, especially for smaller manufacturers, yet they have a limited impact in fixing the poor profitability prospects due to structural cost disadvantages versus foreign

Effectiveness of policy measures and distribution of policy cost — Table 2

Measure	Effect on market share of domestic manufacturers (measured from None to ++++)	Who pays for the policy cost
Core policies		
Local content requirements (LCR)	++++	Clean-tech buyers, mostly private
Import tariffs	++++	Clean-tech buyers, mostly private
Opex production subsidies	++++	Public budget
Capex grants	+++	Public budget
Public procurement	+++ Depends on the size of public procurement.	Public budget
Complementary policies		
Easing permitting processes and removing regulatory barriers	+	N/A
Tech adoption subsidy	None, but can reduce the cost of LCR and import tariffs for technology adopters.	Public budget
Soft loans, guarantees and equity injections	+	Public banks, public budget
R&D investment support	+ Essential to gain and maintain technological leadership and dominance in high-tech segments, but insufficient to respond to foreign cost competition in markets of mature clean technologies.	Public budget
Improvement of other framework conditions (e.g. workforce, legal framework, infrastructures)	+ Helpful if reducing production and transportation costs for domestic producers, easing supply constraints and improving the domestic innovation capacity.	Public budget (if relevant)

Agora Energiewende (2023).

producers. Only a soft loan from the InvestEU programme is unlikely to convince a solar PV manufacturer to expand production in Europe. However these financial instruments are an important complement to capex and opex support and they should be an element of the policy mix.

The US Inflation Reduction Act (IRA) is an example of a policy that fixes cost disadvantages with public funding. Manufacturing subsidies play a central role in the IRA, which are essential to remove the competitive disadvantage of US-based production versus foreign producers. According to analyses by Credit Suisse and the IEA,[41] subsidised US-made solar PV modules, cells and wafers will be cheaper than those manufactured in China. US production of green hydrogen will also become very competitive.[42] Local content requirements apply only to the eligibility for government support ("domestic content bonus"), making sure the subsidies will also attract investment in all steps of the supply chains, including the upstream sectors. However, local content requirements do not apply to the sale of final products in the United States, which would be a more restrictive regulation. While the IRA offers both investment and production tax credits, for manufacturing, the subsidies to operating expenditures play a key role and the US production tax credits are particularly attractive for companies because of their simplicity and long-term coverage.

In addition to these core policies, other complementary policies also help to increase EU manufacturing (see table 2 above). This includes investment in relevant R&D and innovation capacity. Furthermore, conditions like skills and infrastructure are important to enable the desired level of EU manufacturing investment and to ensure its success over the long term. Investment in training, retraining and relevant education is essential for Member States to scale up production rapidly while increasing local employment.

R&D and innovation should be supported for European manufacturers to compete in high value-added market segments and to narrow existing competitiveness gaps through productivity enhancements. The availability of energy and transport infrastructures will make new investment possible and existing plants more productive. Nevertheless, these measures by themselves will not be sufficient to rapidly attract investment into Europe. As the analysis has shown, very significant production and investment subsidies – similar in magnitude to the US Inflation Reduction Act – are needed to attract investment into clean-tech manufacturing in Europe.

41 IEA (2022), Renewables 2022: Analysis and forecast to 2027; Credit Suisse (2022) US Inflation Reduction Act: A catalyst for climate action, Treeprint.

42 Credit Suisse (2022) US Inflation Reduction Act: A catalyst for climate action, Treeprint.

8 EU- versus national-level funding: Amounts and geographical allocation

The cost assessment by Roland Berger for the policy scenarios offers an understanding of the total expenditures associated with different EU manufacturing targets, while an assessment of public funding needs requires further steps. Costs will be split between the private and public sectors and the latter will be divided between national budgets and EU funding instruments.

For the purpose of this analysis, we assume that policy-makers will rely on measures that eliminate the cost disadvantage of EU manufacturers rather than imposing costs on EU consumers and investors through "Buy European" regulation or import tariffs.

We assume that investment costs are supported between 20 and 40 percent, depending on the sector, to ensure the private sector takes sufficient stake in the projects. Opex is then supported in a way to eliminate most of the cost gap of EU producers relative to the most competitive foreign producers in the sector. For the calculation, no specific instrument is assumed – tax credits, contracts for difference or public procurement with local content requirements fit in here. The weight of national- and EU-level funding depends on the scenario.

Figures 11 and 12 show the distribution of public funding needs between the EU and Member States for the EU-coordinated and the nationally driven scenarios.

In the **EU-coordinated scenario**, the EU takes the lead in coordinating and funding clean-tech manufacturing projects across Europe, while requiring national co-financing for a quarter of the subsidies provided.

→ The EU policy is implemented via large funding instruments to which all Member States have access, similar to the Innovation Fund. This instrument should be endowed with around 30 billion euros in the current EU budget period (2021–2027) and triple its size to 94.5 billion euros in the next EU budget period (2028–2034).
→ Before 2027, funding should be equally spent between capex and opex support, as in this phase most of the scaling up occurs and it takes time for plants to enter operation.
→ In the next EU budget period (2028–2034), the cost of opex support rises almost fivefold, as all plants are fully operational and demand for their products reaches higher levels. The dominance of opex support occurs even if the support is set to be reduced by 5 percent per year after 2030, in all scenarios.
→ Batteries and solar PV components receive the vast majority of the funding because of the large cost disadvantage relative to Asian producers and their large market size. The wind sector also receives some opex and capex support to better compete with foreign rivals and to invest in product and process innovation.

In the **nationally driven scenario**, the sectoral composition of the funding provided is the same, but the EU plays only a minor role.

→ We envisage here a smaller EU instrument of around 10 billion euros in 2023–2027 to offer targeted support to the countries or regions most in need, for instance as a complement to Cohesion policy.
→ Potential complementary measures like loan support through the RRF or InvestEU are not included in these calculations, which focus on non-repayable transfers. Loan support belongs to the portion of costs that we allocate to the private sector – as loans are eventually repaid – which is

not displayed in the charts. It is important to highlight again that loans to manufacturers, provided for instance under the InvestEU programme, can help remove financing barriers and reduce the cost of capital, but they are not the right instrument to address the structural cost disadvantage caused by expensive input factors and low productivity.

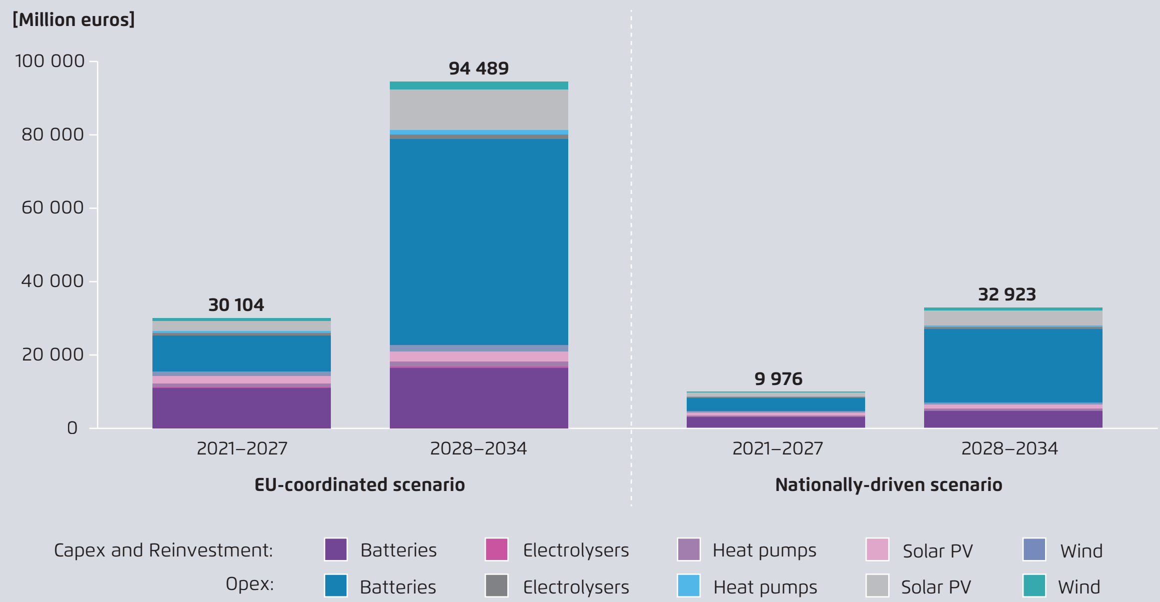
→ National co-financing needs are small before 2027 and become more sizable for Central and Eastern European (CEE) countries over the next EU budget period (figure 12). As a percentage of GDP, the costs are below 0.1 percent annually in Southern, Western and Northern Europe in both scenarios. CEE countries would instead need to spend on average 0.3 percent of GDP in 2028–2034 in clean-tech manufacturing support, mostly for batteries, if support is mainly carried out at national level.

→ The actual burden on Member State's budgets will likely be lower than these figures suggest, because part of the fiscal support may come in the form of corporate and real estate tax exemptions, i.e. foregone tax revenues. The new plants are also expected to generate fiscal revenues, not analysed here, that can at least in part offset the cost of public support. Moreover, measures like the extension of the carbon border adjustment mechanism (CBAM) to clean-tech equipment and materials could narrow the cost disadvantage of EU manufacturers – up to one-third for solar PV modules according to McKinsey[43] - and reduce the intensity of opex support.

43 https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/building-a-competitive-solar-pv-supply-chain-in-europe

Distribution of EU funding needs for clean-tech manufacturing by scenario and EU budget period — Cumulative amounts, constant 2023 prices

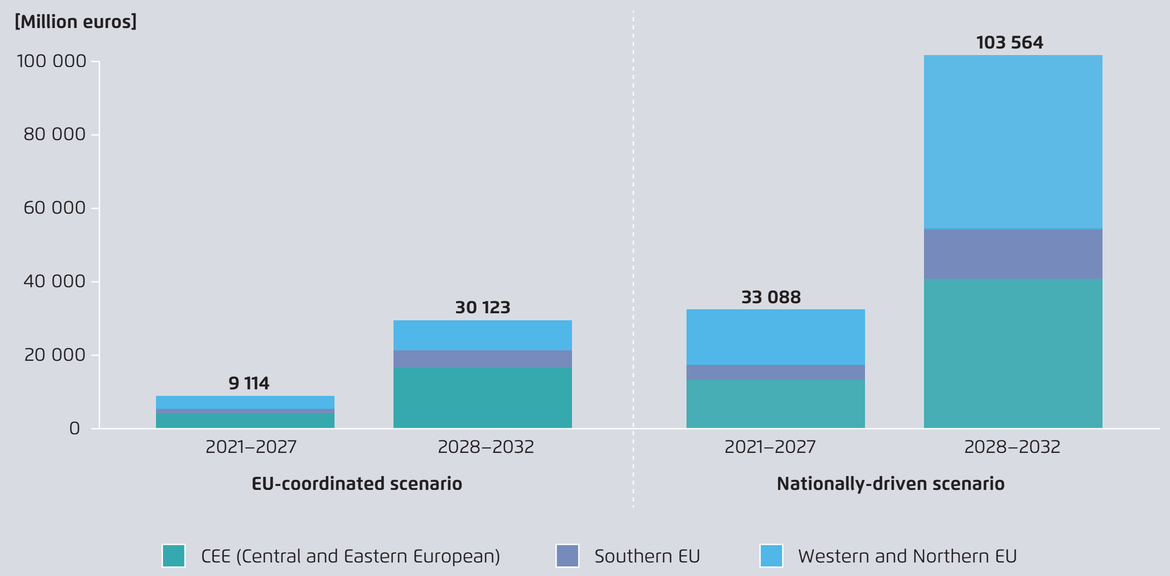
Figure 11



Agora Energiewende (2023) based on Roland Berger data.

Distribution of national public funding needs for clean-tech manufacturing by scenario and EU budget period — Cumulative amounts, constant 2023 prices

Figure 12



Agora Energiewende (2023) based on Roland Berger data.

The **estimated EU-wide fiscal costs** of both scenarios are in line with existing estimates for the public spending needs of the US's IRA. The sum of the EU and national spending needs is between 164 and 180 billion euros in the two scenarios for 2022–2034, which is less than what Credit Suisse estimates will be the possible federal US spending for manufacturing subsidies due to the IRA by 2032 (257 billion US dollars, equivalent to circa 236 billion euros). However EU-wide fiscal costs are equivalent to around one percent of respective GDP in cumulative terms.

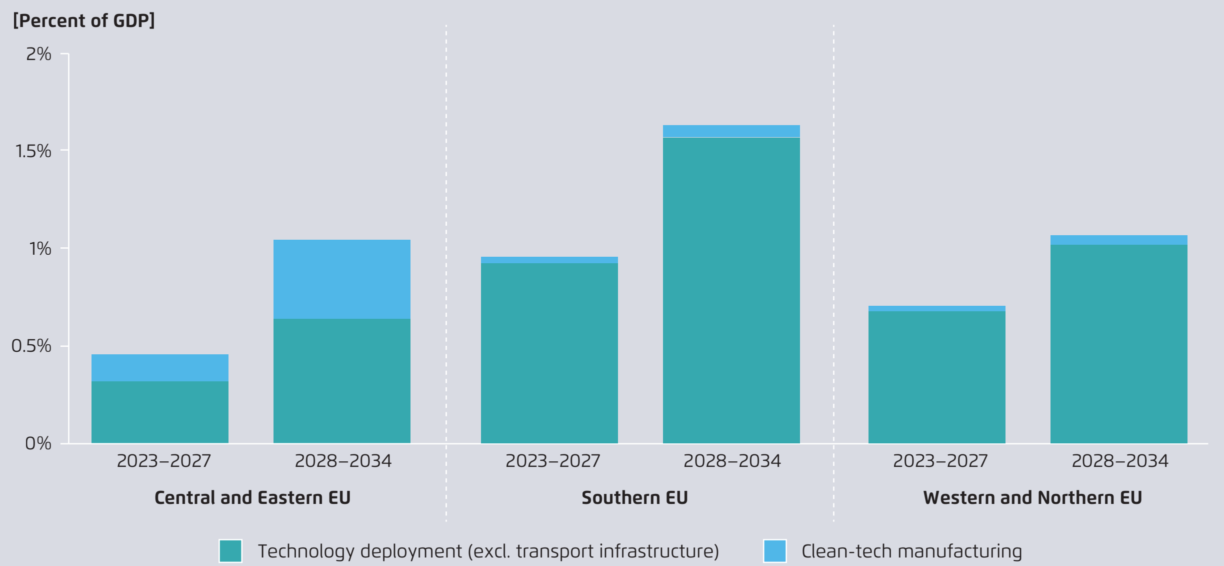
9 Public funding to increase EU clean-tech manufacturing comes on top of much larger public funding needs to accelerate the deployment of clean technologies in Europe

Even if they are significant, the public funding needs for the resilience of EU clean-tech value chains are small compared to those on the technology deployment side. Figure 13 shows the annual public funding needs for clean-tech manufacturing by macro-region, considering a different scenario in which manufacturing will be supported in the best locations, as in the EU-coordinated scenario, but most of the public financing comes from Member States as in the nationally-driven scenario. These numbers reveal how much it would cost national governments to support production in the best locations with minimal EU co-funding. Compared to the nationally driven scenario, funding needs are higher in the CEE region and slightly lower elsewhere. The chart also shows the annual national public spending requirements for climate investment – excluding transport infrastructure – at levels compatible with the EU's 2030 climate targets. These numbers are the total funding needs beyond the EU funding available to Member States in each period.[44] The numbers for the period 2028–2034 exclude a renewal of the one-off Recovery and

44 The methodology is described in the technical documentation of Agora Energiewende's EU Climate Funding Tracker available at: https://www.agora-energiewende.de/en/publications/eu-climate-funding-tracker/

National public funding needs for clean-technology deployment and manufacturing (spending needs not covered by EU funds) — Annual averages

Figure 13



Agora Energiewende (2023) based on Roland Berger data.
Note: the chart shows the public funding needs net of the EU grants available to Member States.

Resilience Facility and they should be interpreted as a lower bound for the CEE region, where investment needs will rise rapidly after 2030, depending on which 2040 EU climate target will be set.

Public funding needs for technology deployment and energy infrastructures are, in most of Europe, much larger than those for increasing EU clean-tech manufacturing. In the CEE region, the national funding needs are more balanced between the two categories for two reasons. First, EU funds cover a large share of the CEE countries' climate investment needs. Second, the CEE region is expected to receive a significant amount of clean-tech manufacturing investment. EU co-financing in the next EU budget period will play an important role to ensure both types of public investments will be carried out. Clean-tech manufacturing investment will serve both the EU's environmental and convergence goals, supporting economic development in the CEE region while strengthening the resilience of the EU-wide transition to net zero.

10 A policy package to scale EU clean-tech manufacturing that will strengthen value-chain resilience and Europe's industrial base

Scaling EU manufacturing of clean technologies to minimum levels and specifically targeting the most important vulnerabilities would act as an insurance against potential risks to clean-tech value chains. It should thus be one element for increasing the resilience of Europe's clean energy transition, together with efforts to diversify supplies and increase circularity.

This insurance comes at a price, given the structural cost disadvantages of clean-tech production in Europe compared to best-in-class production elsewhere (see table 3 below). A credible approach to closing the opex cost gap is thus essential. However, to create lasting value, it should be embedded in a broader package of policies that ensure long-term competitiveness without support. The proposed Net Zero Industry Act and Critical Raw Materials Act set important starting points, particularly as regards securing access to critical raw materials, simplified and accelerated permitting of priority projects, regulatory sandboxes, skills development and job creation. But they will not achieve the objectives of the EU's Green Deal Industrial Plan.

Based on the above analysis, we recommend adding the following seven elements to a policy package for scaling EU clean-tech manufacturing to make a lasting contribution to the resilience of Europe's clean energy transition:

1. A Clean-Tech Manufacturing Fund for closing the opex cost gap;
2. A clean technology manufacturing contribution to provide revenues for the fund;
3. Privileged access to favourable investment and finance costs;
4. Market differentiation of EU-manufactured clean-tech products;
5. Long-term demand creation for EU-manufactured clean-tech products based on superious sustainability performance;
6. Attracting leading clean-tech suppliers to establish manufacturing in Europe, while using safeguards to achieve a gradual de-risking of value-chain dependencies; and
7. Investment into strategic innovation projects in clean-tech sectors.

It also is important to underscore that a policy package that strengthens the resilience of the EU's energy transition would have important side-benefits for Europe's industrial base, regarding employment in manufacturing proper as well as in sectors supporting the deployment of clean technologies.

As already discussed, in an open economy like the European Union it should not be taken for granted that a local production base of clean technologies will develop without targeted policy intervention, as proven by the European solar PV industry. Even in the success case of the wind industry, which currently employs more than 200 000 people in Europe, the pressure from international competition and weak demand is becoming more and more evident. A strong clean-tech production base will create demand for other manufacturing products and support EU industry across the board.

The creation of a strong domestic battery manufacturing sector will ensure that jobs and value added in the automotive industry will be retained in Europe during the transition to electric mobility. The automotive industry is one of the most important manufacturing sectors in Europe and the part of the value chain related to the production of components for internal combustion engines will be lost with the transition. In the supply chain for electric vehicles, the key step of battery manufacturing is currently dominated by producers from Asia. As the industry is still in its early stages, Europe can gain market shares in the sector with the set of policy interventions proposed in this paper.

Timely intervention in nascent industries like batteries or electrolysers is also essential because of path dependencies in industrial development. Given strong international competition, the lack of a coordinated EU industrial policy response today could lead to an increasingly marginal role of EU-based manufacturing. And catching up later on would be more expensive, if possible at all, because international competitors would have gained significant expertise, knowledge and economies of scale that could consolidate into a dominant position in the market. It is also easier to gain market shares in a growing market, for example during the clean-tech deployment scale-up through the 2020s.

10.1 A Clean-Tech Manufacturing Fund for closing the opex and capex cost gap

The analysis by Roland Berger shows that unit manufacturing costs for solar PV, wind, electrolysers, heat pumps and batteries are 14–70 percent higher in Europe than best-in-class manufacturing costs elsewhere (see table 3).

The sum of EU and national spending needs for this are between 10 and 30 billion euros for the current EU budget period (2021–2027). The proposed "Strategic Technologies for Europe Platform" (STEP) (see infobox 2 below) alone would not be able to cover the EU funding needs for this period, even in our scenario with minimal EU solidarity. The envisioned 10 billion euros top-up to the STEP will also serve the digital and biotechnology sectors, whose funding needs are not part of Roland Berger's analysis and have not been estimated elsewhere. Recent announcements for the chip industry suggest these sectors have high public funding requirements and are likely to use a significant share of the top-up to STEP. One example is the subsidy package of about 10 billion euros that Intel will receive from the German government to build a new chip production site in Magdeburg.

For the next EU budget period (2028–2034), public funding requirements will triple. We calculate that between 32.9 and 94.5 billion euros would be needed for clean-tech manufacturing support. These amounts are around 3% and 8% respectively of the total size of the current EU multiannual budget.

While the public funding challenge for scaling clean-tech manufacturing seems manageable until the end of the current EU budget period (2021–2027),

Unit manufacturing costs – opex [EUR/kW and EUR/kWh for batteries] — Table 3

Technology	Best-in-class	EU	Difference
Solar PV	200	266	+33%
Wind (onshore)	601	684	+14%
Electrolysers (alkaline)	111	189	+70%
Heat pumps	224	265	+18%
Batteries (NMC)	76	113	+49%

Roland Berger (2023).

Infobox 2: Strategic Technologies for Europe Platform (STEP)

The Strategic Technologies for Europe Platform (STEP) was announced on 20 June 2023 as part of the EU's response to the competitive challenges it is facing in the production of critical technologies, in the clean-tech, bio-tech and other digital technology sectors. STEP mainly reinforces and leverages existing EU funds, providing incentives for Member States to reprioritise funding programmes. The proposal further aims to top up existing funds with an additional 10 billion euros, of which half are destined for the Innovation Fund and the remainder flowing into InvestEU, Horizon Europe and the European Defence Fund.

it seems quite daunting for the next EU budget period (2028–2034), both in view of the much larger sums needed as well as the many competing national and sectoral interests in the future EU budget.

Against this background, we recommend that the EU Commission proposes to establish a dedicated Clean-Tech Manufacturing Fund. Establishing a special purpose instrument at the EU level is justified considering:

→ the economic and political importance of Europe's transition to climate neutrality;
→ the importance of more resilient clean-tech value chains from critical raw and refined materials, to components and final products;
→ the important contribution of scaling EU clean-tech manufacturing to enhance the resilience of Europe's transition to climate neutrality;
→ the distinct time-frame during which support is most needed;
→ the efficiency and solidarity gains from an EU-level instrument that complements national support measures; and
→ the need to avoid a trade-off between "insurance premium payments" for enhancing the resilience of Europe's energy transition and the much larger public funding needed to support clean-tech deployment in line with Europe's climate and energy targets.

Clean-tech deployment support will foreseeably become a core issue in the next EU multiannual budget and should be linked to national energy transition priorities, whereas the scaling of clean-tech manufacturing has EU-wide resilience benefits irrespective of where manufacturing happens.

We recommend that the Clean-Tech Manufacturing Fund would:

→ be established outside the regular EU budget (similar to the EU Innovation Fund);

Infobox 3: How the Clean-Tech Manufacturing Fund would interact with a potential (EU) industry power price

Energy costs make up a significant part of overall costs, particularly as regards raw materials processing and refining in clean-tech value chains. A potential (EU) industry power price – as is currently being debated in some Member States and at the EU level – would thus constitute an important component of closing the opex cost gap for clean-tech manufacturing in Europe.

Setting aside debates on the financing and design of an (EU) industry power price, such instrument would synergistically interact with the Clean-Tech Manufacturing Fund if support from the fund is allocated on the basis of competitive tendering. In this case, beneficiaries from the clean-tech manufacturing fund would include a guaranteed industry power price in the calculation of their bids.

- be supplied from a dedicated clean-tech manufacturing contribution (below 10.2) and, as available, further EU or national funds;
- be equipped with up to 100 billion euros in constant 2023 prices until 2034;
- operate from 2026 to 2034;
- offer support for net-zero strategic projects on a competitive basis, with gradually declining support per unit of production to incentivize early uptake;
- link support commitments to the achievement of scale and superior sustainability performance across the value chain; and
- enable a combination of support through the EU Clean-Tech Manufacturing Fund and nationally available funds.

The governance of the fund could draw on experience with the administration of the EU Innovation Fund that involves the EU Commission, the European Climate, Infrastructure and Environment Agency (CINEA), the European Investment Bank, and participating countries.

Leading technology providers from countries with which the EU currently faces over-dependencies should be eligible for support subject to certain conditions (below 10.6).

The desirable combination of EU clean-tech support with complementary national funding and the need for national funding to address shortfalls in EU support in the short term may also require further nuances to **EU state aid rules:**

- First, relevant EU state aid rules[45] should be extended beyond the current deadline (end of 2025) until the end of the current EU budget (2027) and be updated again with the beginning of operations of the Clean-Tech Manufacturing Fund. Policy certainty is important for investors, as plants need regular reinvestment for proper functioning and upgrades;
- Second, investments that qualify as "net-zero strategic projects" under the NZIA, should get automatic state aid approval if support remains

45 Temporary Crisis and Transition Framework for State Aid measures to support the economy following the aggression against Ukraine by Russia (2023/C 101/03) of 17.3.2023.

Infobox 4: A side note on the space for national clean-tech spending under a reformed EU Fiscal Pact

National clean-tech manufacturing subsidies add to an already long list of public spending needs that weigh on public finances of Member States, while at the same time EU fiscal rules could impose fiscal consolidation policies in several Member States.

Scaling up investment in decarbonisation to the level needed to reach the 2030 EU climate targets require Member States' national public spending to increase by 1–2 percent of GDP by 2027 compared to the 2010s average.* New policy priorities in the areas of defence and security of supply further add to the spending needs. At the same time, the EU fiscal rules will apply again from 2024 and require several Member States to reduce their fiscal deficits, whether the current or newly proposed rules apply.

The European Commission proposal for reform of the rules would lead to less aggressive fiscal consolidation in high-debt countries compared to the old rules. Regrettably, the Commission's reform proposal does not sufficiently safeguard public investment, especially when it comes as a structural and permanent increase in public spending like in the cases of industrial policy and climate change mitigation.** For instance, the proposed reform would require Italy to reach a primary surplus of 2.8–3.2 percent of GDP by 2027, equivalent to a fiscal adjustment of 18–27 billion euros.***

Easing the fiscal rules would not however help countries with structurally low fiscal space. In these cases, an increase in EU solidarity with a joint funding instrument is more effective to ensure national investments will be carried out. This provides another argument in support of a dedicated EU instrument to support the scaling of clean-tech manufacturing in Europe.

* Odendahl and Baccianti (2022), "How to make EU fiscal rules compatible with net zero", Centre for European Reform.

** Darvas (2023), Fiscal rule legislative proposal: what has changed, what has not, what is unclear? Bruegel; Lindner and Redeker (2023), "It's the politics, stupid" - don't squander this golden opportunity for reforming the fiscal rules, Jacques Delors Centre.

*** Il Sole 24 Ore, "Per rispettare il nuovo Patto UE sforzo extra da 18–27 miliardi," 21 June 2023.

within certain boundaries (intensity, thresholds, duration);

→ Third, maximum aid limits in section 2.8 of the Temporary Crisis Framework should be reviewed against the public funding needs described above. For the sectors requiring the largest support, namely solar PV and batteries, competitive clean-tech manufacturing means investing in larger plants to exploit economies of scale. Higher national state aid is possible, according to paragraph 86 of the Temporary Crisis Framework, however, it requires specific approval by the Commission and demonstration that larger aid is offered by a third country for an equivalent investment. Given the security of supply considerations and the intrinsic logic of reaching economies of scale for clean-tech manufacturing to be competitive, higher aid levels should depend less on foreign policies.

10.2 A clean-technology manufacturing contribution to provide revenues for the fund

We recommend that the Commission proposes a clean-technology manufacturing contribution as a dedicated, distinct revenue source for the clean-tech manufacturing fund.

A dedicated revenue source for scaling clean-tech manufacturing in Europe is warranted considering the economic and political importance of Europe's transition to climate neutrality, the specific security interest in a reliable supply of critical raw and refined materials, components and clean-tech products to the EU market, the contribution of scaling EU clean-tech manufacturing to enhancing the resilience of Europe's transition to climate neutrality and the specific time-frame during which support is most needed.

One option worth exploring could be to specifically **earmark a share of national ETS revenues for clean-tech manufacturing support**. With the tightening of the ETS cap and rising carbon prices, revenues from the auctioning of ETS allowances rose from 3.1 billion euros in 2013 to 25 billion euros in 2021,[46] and are expected to increase further if carbon prices continue to rise.[47] Some countries in Europe are already using national ETS revenues to this end.[48] A formal amendment to the underlying rules could provide clean-tech manufacturers with investment certainty well into the next decade.

Another option worth exploring could be a **levy on material intensive products sold on the EU Single Market**.[49] In this case, the clean-technology manufacturing contribution should:

46 https://www.eea.europa.eu/ims/use-of-auctioning-revenues-generated.

47 https://www.umweltbundesamt.de/en/press/pressinformation/emissions-trading-rings-up-record-revenues-more.

48 For example, the German „Klima- und Transformationsfonds" i.a. supports the scaling of renewable hydrogen production (https://www.bundesregierung.de/breg-de/aktuelles/ktf-sondervermoegen-2207614).

49 Stede et alii (2021) Carbon Pricing of Basic Materials: Incentives and Risks for the Value Chain and Consumers, DIW.

- be levied on all material-intensive products sold in Europe proportional to their embedded CO_2 emissions. It would thus be a revenue source coming from industry and going to industry;
- the levy should be calculated based on the weighted materials of products sold in the internal market and would thus apply to EU-manufactured products as well as to imports.

Calibrating such a levy on embedded CO_2 emissions is consistent with the progressive need of companies to evaluate and monitor the carbon intensity of their value chains in the context of the EU Carbon Border Adjustment Mechanism as well as in view of the progressive introduction of low-carbon or carbon-neutrality standards. Responsibility for collecting the contribution would be with national governments. Similar to the plastics own resource,[50] the EU could propose a common methodology for calculating the contribution and also calculate the respective national contributions based on the amount of material-intensive products sold. However, national governments would decide how to finance their respective contributions to the Clean-Tech Manufacturing Fund.

Regardless of the option eventually chosen, the key point for clean-tech manufacturers will be the forward visibility of distinct and dedicated public funding available in support of scaling clean-tech manufacturing in Europe.

10.3 Privileged access to favourable investment and finance costs

Capital expenditure (capex) makes up a sizeable cost component of clean-tech manufacturing investments. Capex support in the form of grants, zero-interest credits or bank guarantees have an indirect effect on the competitiveness of a plant by reducing amortisation costs and the cost of capital.

With rising inflation – driven in particular by rising prices for energy and food – the European central bank and other central banks in the EU have increased their interest rates, making cost of capital more important.

Against this background, investments recognised as net-zero strategic projects under the Net Zero Industry Act should automatically become eligible for soft loans through commercial banks that are backed by dedicated lending from the European Investment Bank and national development banks (e.g. KfW in Germany, AFD in France, BGK in Poland) as well as other suitable instruments for reducing investment risks (like bank guarantees, etc).

10.4 Market differentiation of EU-manufactured clean-tech products

Public support to EU clean-tech manufacturing should be linked to permanent efforts of supported companies to achieve superior sustainability performance across the value chain. This would allow for the market differentiation of EU clean-tech products. Superior performance should start with transparent tracking and reporting on embodied carbon emissions, on respect for environmental and labour standards throughout the value chain and recyclability. Transparency about and superior performance on sustainability will enable public and private purchasers to pay a slight premium for clean technologies manufactured in Europe.

The approach of the new EU Batteries Regulation,[51] which will gradually introduce new standards for batteries sold in Europe as regards sustainability and

50 https://commission.europa.eu/strategy-and-policy/eu-budget/long-term-eu-budget/2021-2027/revenue/own-resources/plastics-own-resource_en

51 Regulation (EU) 2023/1542 of the European Parliament and of the Council of 12 July 2023 concerning batteries and waste batteries.

safety, supply-chain management, labelling and information, recycling and end-of-life management, should be taken as a reference point for other clean technologies. Standards could be set through the framework established by the new Ecodesign for Sustainable Products Directive. Prioritising standard development for clean technologies important for the transition to net-zero emissions would enable the early market differentiation of EU-manufactured clean-tech products.

10.5 Long-term demand creation for EU-manufactured clean-tech products based on superior sustainability performance

Reliability of future clean-tech demand in Europe in terms of volume and quality is an important element to decide on the siting of clean-tech manufacturing in Europe. The European Union and its Member States are in an excellent position in this regard.

- → The EU Climate Law establishes binding targets to reduce greenhouse gas emissions in Europe by at least 55 percent by 2030, based on 1990 levels, and to reach climate neutrality continent-wide by latest 2050.
- → The headline climate targets are underpinned by a broad set of horizontal and sector-specific EU laws, most prominently the EU Emissions Trading System, the EU Renewable Energy Directive and the CO_2 standards for cars and light duty vehicles.
- → Countries throughout Europe are currently updating their National Energy and Climate Plans (NECPs) before 2030 in view of the Fit for 55 legislative package.
- → Updated national climate and energy legislation of countries in Europe will – at minimum – implement requirements under the Fit for 55 legislative package but could go beyond that.

Taken together, investors into clean-tech manufacturing in Europe should, by mid-2024, have a high level of confidence in national demand volumes for clean tech in Europe until at least 2030, and for countries in Europe with robust long-term strategies also beyond that date.

Clean-technology deployment will also play an important role in forthcoming discussions on the next multi-year EU budget (2028–2034). Current minimum shares of EU spending on climate action will foreseeably only be the starting point in this debate, given the accelerating climate crisis.[52]

If capex and opex support to EU manufacturers of clean-tech products is linked to the superior sustainability performance of these products across the value chain (above, 10.1), then the resulting market differentiation of EU-manufactured clean-tech products (above, 10.4) could and indeed should be used as key criteria in steering EU demand for clean-tech products.

Important levers in this regard are public procurement, publicly supported private investments and industrial alliances. Long-term, reliable market demand for clean-tech products with a superior sustainability performance, even if these come with potentially higher unit costs, will help to reduce some cost disadvantage for EU-manufactured clean-tech production.

Focusing on superior sustainability performance of clean-tech products manufactured in Europe should be prioritised over local content requirements ("Buy European"), although such requirements could be justified whenever public funding is involved.

Public procurement. In 2020, government expenditure on works, goods and services amounted to about 15 percent of EU GDP. Systematically linking public procurement decisions to accelerated climate action

52 Currently, countries are committed to allocate 30 percent of the regular 1.1 trillion euros multi-year EU budget and 37 percent of Europe's 750 billion euros economic recovery budget 'Next Generation EU' to climate action.

is seen as an important lever to reduce greenhouse gas emissions in Europe.[53]

EU procurement legislation – with few sector-specific exceptions – allows but does not oblige public authorities in Europe to use environmental or social aspects as part of the award criteria to identify the most economically advantageous tender. Currently, however, the Commission estimates that more than half of relevant procurement contracts are based on lowest price criteria only.[54]

Against this background, Articles 19 and 20 of the proposed Net Zero Industry Act would – if adopted as proposed – make it mandatory to apply environmental and resilience considerations when purchasing clean-tech products. Contracting authorities and contracting entities would be obliged to give the tender's sustainability and resilience contribution a weight between 15 percent and 30 percent of the award criteria. This seems a sensible way to balance competing interests.

To support effective implementation of this element of the Net Zero Industry Act, the European Commission should quickly develop guidance for public purchasing entities to ensure that public procurement decisions work in support of clean-tech manufacturing in Europe.

Publicly supported private investments. Public support plays an important role in ensuring the scale of private investments needed into the deployment of clean energy technologies. Public funding is effective in mobilizing private capital when it targets firms and households facing barriers to credit access or when it mitigates investment risks for investments that have uncertain returns or particularly high initial capital requirements (e.g. most renewable energy technologies, deep renovations or large infrastructure projects). De-risking is particularly important and there are several well-tested instruments (e.g. carbon contracts for difference, power purchase agreements or tax credits) that influence the risk/return ratio of investments. Well-targeted EU and national public funding is a critical lever to scale private investments into clean-tech deployment to levels consistent with the EU's pathway to -55 percent greenhouse gas emissions by 2030 and climate neutrality by latest 2050.[55]

Industrial alliances. The EU should also use its convening and coordinating power to link companies involved in clean-tech manufacturing with financiers of clean-tech companies and companies involved in installing clean technologies. Such industrial alliances could set – value chain per value chain – bottom-up deployment targets for key technologies to increase certainty for investment in manufacturing and help investors invest at a competitive scale from the start.

10.6 Attracting leading clean-tech suppliers to establish manufacturing in Europe, while using safeguards to achieve a gradual de-risking of value-chain dependencies

The political resolve of Europe to reduce current over-dependencies through diversification of supplies and scaling of domestic manufacturing is not a signal against a rules-based, open international trading system, but a gradual de-risking in support of

53 Stockholm Environment Institute (2023), Green Public Procurement: a key to decarbonizing construction and road transport in the EU. Available at https://www.sei.org/wp-content/uploads/2023/02/green-public-procurement-eu.pdf.

54 See Commission Staff Working Document SWD(2023) 219 final of 19.6.2023, p. 46.

55 For details see Agora Energiewende (2021): Matching money with green ideas. A guide to the 2021–2027 EU budget; Agora Energiewende (2022): Delivering RePowerEU: A solidarity-based proposal for financing additional green investment needs; and the EU Climate Funding Tracker on the Agora Energiewende website.

mutually beneficial international trade. Trade diversification and security of supply go hand in hand.

The Critical Raw Materials Act sets the objective to reduce current supply dependencies to a maximum 65 percent of supplies from a single third country of any strategic raw material, unprocessed and at any stage of processing, by 2030. Special consideration can be given to countries with whom the EU has established a Strategic Partnership on raw materials that gives greater assurances regarding supply risks. So, Europe prefers a stepwise and nuanced approach to de-risking current over-dependencies.

Indeed, we would recommend that EU countries recognise the necessity to cooperate with technology and value-chain leaders and attract leading clean-tech suppliers to establish manufacturing in Europe. This is compatible with efforts to achieve a gradual de-risking of current value-chain dependencies if public support is accompanied by appropriate safeguards that ensure a lasting commitment from companies that decide to establish production in Europe.

10.7 Investment into strategic innovation projects in clean-tech sectors

One exciting feature about net-zero strategic technologies is continuing technical progress that is reducing costs and making clean technologies increasingly affordable, and indeed often cheaper than their polluting predecessors.

This being said, rapid technical progress also poses a challenge to targeted and effective public support for scaling manufacturing and deployment.

Continuous investment into world-class strategic innovation projects in Europe, particularly as regards quality, efficiency, circularity and sustainability, will help EU companies maintain an edge over their competitors and ensure competitiveness of EU clean-tech manufacturing over time.

Annex 1: Methodology to quantify value chain risks as basis for calculating appropriate shares of EU manufacturing

The analysis undertakes a risk assessment of each current manufacturing sector in the EU and its value chains and sets a quantitative rating for a set of ten identified concrete risks. For each of the risk factors listed in the scoreboard shown below, a technology-specific proxy is used to determine the risk level, for example the highest share of a single supplier country in a value chain for the supplier dependence parameter. The individual risk scores are added to calculate the overall risk assessment score.

From that risk assessment score, an appropriate minimum EU manufacturing share to mitigate the risk exposure is derived. The different manufacturing shares combined with (relatively higher) costs per unit of production enable an estimation of the cost of scaling EU manufacturing.

This methodological approach gives a robust indication of the overall level of risk for a specific value chain, which is important to enable an informed comparison between sectors and value chains. However, the overall risk score may mask very high individual risk factors that could disrupt an entire value chain. Against this background, such very high individual risk factors are made explicit in the description of each value chain (see section 4 above) and also inform recommendations for specific measures.

Risk assessment score — Table 4

Category		Risk	Weight	Score
Economical	1	Demand and supply gap	10%	0–1
	2	Supplier/partner dependence	10%	0–1
	3	Material and labour shortage	10%	0–1
Geopolitical	4	Regulation (e.g. ESG)	10%	0–1
	5	Political risks (e.g. sanctions)	10%	0–1
Technological	6	Incremental tech. innovations	10%	0–1
	7	Disruptive technologies	10%	0–1
Geographical	8	Blockade of transport/trade routes	10%	0–1
	9	Force majeure (environmental)	10%	0–1
Digital	10	Digital malfunctions	10%	0–1

Roland Berger (2023).

Annex 2: Financial and technological assumptions

Financial assumptions	Table 5
Inflation	Differentiation across countries according to International Monetary Fund forecast, converging towards 2 percent by 2029, stable rate onwards. Included in all financial components to account for country differences (opex, capex and reinvestments)
Discount factor	Discounting with EU-27 average of ten-year government bond forecast to account for future value of money which is held in reserve in the EU budget. Equal across technologies, stable values after 2032. No consideration of tax shield
Capex investments	100% investments in concerning year (year with capacity requirement minus lead time), no depreciation period
Reinvestments	Stable reinvestments for base in terms of 1/lifetime per year; year-specific reinvestments for all newly built capacity after lifetime (reduced by lead time)
Exchange rate	USD/EUR of 1.05 for UMC cost conversion

Roland Berger (2023).

Technological assumptions	Table 6
Lifetime	7 years machinery lifetime for reinvestment cycles, except for wind with 6.5 years (excl. building lifetime); half years are rounded down to avoid malfunctioning
Lead time	Investments 2–3 years before capacity installation (2 for PV and Wind, except for Wind tower with 2.5, rest 3 years); half years are rounded up to avoid delays
Ramp-up of target levels	Gradual increase with full target level achieved by 2030, start of ramp up in 2025/2026 according to lead time with 30 percent of target (20pp steps with flattening steps in last years of 10pp)
Unit manufac-turing costs	Country-specific for energy and labour according to electricity and labour cost levels of each country, EU-27 level for material and Selling, General and Administrative Expenses (SG&A/Overhead); stable over years for energy and labour, declining trend for material and SG&A/Overhead based on specific technology learning rate.
Capex costs	Country-specific according to construction cost index for each country, stable development over years

Roland Berger (2023).

Annex 3: Details of estimated manufacturing costs and assumed levels of support

Summary of total costs by technology and scenario, as a difference relative to the baseline — Table 7

Cumulative deviations from baseline, million euros		2022–2027			2028–2034			DCF 23–35 (discounted)		
		NZIA	EU	National	NZIA	EU	National	NZIA	EU	National
Battery	Capex and Reinvestment	65,531	23,473	31,296	101,710	41,083	54,502	149,915	59,147	78,594
	Opex	6,291	2,193	2,237	296,731	127,937	130,897	283,117	122,622	125,456
	Total	71,822	25,666	33,532	398,441	169,019	185,400	433,032	181,769	204,050
Electrolyser	Capex and Reinvestment	201	-2	4	863	205	298	1,148	271	396
	Opex	-17	-17	-17	5,395	1,269	1,480	5,036	1,201	1,402
	Total	184	-19	-13	6,258	1,474	1,778	6,184	1,472	1,798
Heat pump	Capex and Reinvestment	-18	-18	-18	1,936	434	570	3,297	743	974
	Opex	-7	-7	-7	5,979	1,424	1,643	5,721	1,360	1,569
	Total	-25	-25	-25	7,915	1,858	2,212	9,018	2,103	2,543
Solar PV	Capex and Reinvestment	6,281	6,519	8,495	7,980	8,310	10,798	12,862	13,377	17,412
	Opex	4,745	5,804	6,065	31,901	39,173	41,039	33,529	41,149	43,095
	Total	11,026	12,323	14,560	39,881	47,483	51,836	46,391	54,526	60,507
Wind Offshore	Capex and Reinvestment	871	155	214	3,204	480	662	3,610	546	754
	Opex	928	328	336	29,880	7,210	7,473	28,630	7,002	7,252
	Total	1,799	483	550	33,084	7,689	8,135	32,239	7,548	8,006
Wind Onshore	Capex and Reinvestment	1,194	-	-	3,628	202	279	4,763	229	316
	Opex	473	473	473	47,208	8,272	8,462	44,523	8,279	8,461
	Total	1,667	473	473	50,836	8,474	8,742	49,286	8,508	8,777

Roland Berger (2023).

Annex 4: Calculation of public funding needs

This section describes how the amount of EU and national public funding requirements are calculated. The Roland Berger analysis produced detailed data on total capital and operational expenditures associated with each scenario, until 2040. These figures cover all costs related to setting up, maintaining and operating a given level of manufacturing capacity and do not differentiate the part of the costs paid by the private sector and the part funded by the public sector. As discussed extensively in the paper, capex and opex will have to be supported by governments in most cases, to different degrees depending on the sector.

The public funding requirements are calculated differently for capex and opex. Support to operating expenditures is applied on the unit manufacturing costs defined as the sum of material, energy and labour costs and SG&A costs (overhead costs). Capex grants cover a fraction of the total investment costs in each scenario. The support rates and the distribution of the support costs between the EU and national budgets are reported in Table 8. Opex support is gradually reduced after 2030 by 5 percent per year.

Support rates and cost distribution applied in the calculation of public funding requirements, as percentage of total

Table 8

	Capex			Opex		
	Support rate	Share of support costs		Support rate	Share of support costs	
		EU	National budgets		EU	National budgets
Battery	25	80 / 20	20 / 80	33 / 35	75 / 25	25 / 75
Solar PV	30	75 /25	25 / 75	30 / 33	75 / 25	25 / 75
Wind	20	75 / 25	25 / 75	8	75 / 25	25 / 75
Electrolysers	40	75 / 25	25 / 75	25	75 / 25	25 / 75
Heat pumps	20	75 / 25	25 / 75	18	75 / 25	25 / 75

Agora Energiewende (2023).
Note: when two values are reported, the first refers to the "EU-coordinated" scenario and the second to the "Nationally driven" scenario

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