Between climate action and competitiveness: towards a coherent industrial policy in the EU

Principles for an EU industrial policy for climate action

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Executive summary

Industrial policy is back in the mainstream of economic policy. The Covid pandemic and ensuing supply chain disruptions, as well as intensifying geopolitical competition, have led decision makers and scholars to reconsider the roles of public policy and state intervention in the economy. Moreover, as the EU pushes to transition to a climate neutral economy, China and the US have supercharged the competition for technological leadership and market shares in key clean technologies. The EU has responded to this challenge with different industrial policy initiatives, including the Green Deal Industrial Plan and the 2023 Net Zero Industry Act (NZIA). Yet industrial competitiveness remains one of the main priorities across the political spectrum. Given this renewed interest in industrial policy across the EU, there is an urgent need for a clearsighted approach to industrial policy – **what goals it should pursue, what principles it should be based on, and how it should complement existing policies**. As energy-intensive industries in Europe struggle to transform and the position of EU manufacturers in global markets for key clean technologies is increasingly contested, we argue that a renewed industrial policy effort is needed that sets out to change the structure of the economy in the pursuit of climate-neutrality.

In this work, **we focus on how to leverage industrial policy to make EU industry fit for climate neutrality, reorganising value chains towards a de-fossilised industry**. Industrial policy is discussed in connection with several policy objectives, which can be aligned or in conflict: among them geopolitical considerations such as security of supply and dependence on critical supply chains, but also domestic job creation, regional development, or harnessing the potentials of digitisation. The focus of this paper is mostly on how EU industrial policy can be aligned with the transformation to climate neutrality, followed by a shorter reflection on how such climate-oriented industrial policy can be (better) aligned with efforts to make EU industry more resilient and reduce security risks, and where the respective goals are in conflict.

Where does European industry stand on the way to climate neutrality?

With the rise of industrial policy back to the top of the political agenda, three policy angles are often mixed which we argue should at least conceptually be distinguished from one another. The first one is *competitiveness* of the overall economy – the central focus of the Draghi report's findings. Second, industrial policy has been discussed in the context of the *industry transformation*, i.e. the challenge to hoist incumbent, energy-intensive sectors such as steel, cement and chemicals on a path to climate neutrality. Third, industrial policy can refer to the ramp-up of *key clean technologies* that enable a carbon-neutral future, such as solar PV, wind turbines, and electrolysers. This work sets a clear focus on the two policy domains of "incumbent fossil industries" and "key clean technologies" to improve analytical clarity, and with it our contribution to ongoing debates.

Therefore, leaving broader competitiveness aspects of the overall EU economy aside, **the challenge European industry faces in the transition to climate neutrality is a dual one:** on the one hand, it is about securing leadership for key clean technologies that are essential to the transition (e.g. solar PV, wind, electrolysers), while on the other hand transforming the existing industrial base and its value chains, particularly for energy- and emission-intensive basic material industries (steel, cement and chemicals above all). These two domains overlap where new technologies can help to decarbonise existing value chains, in particular relating to the (direct or indirect) electrification of processes previously operated with fossil inputs, such as electrolysers for green H_2 and large heat pumps.

While **EU leadership is increasingly contested, EU industry still has strengths in both domains**: building up key clean technologies – and the value chains that support them – as well as transitioning incumbent industries (esp. basic industries) on the road to climate neutrality. As a region with a strong industrial base and infrastructure (both physical and R&D), EU industrial policy should coordinate efforts in both domains.

Incumbents in **basic material industries have accepted the need to transition their technological and asset base**, and to some extent their business models, to remain competitive in a defossilised, climate-neutral economy. Increasingly, companies have developed strategies for the transformation, but are struggling to put them into practice. This is mostly due to the availability and costs of infrastructure (electricity grids, energy storage, H2 and CO2 pipelines), the supply of renewable electricity and its cost, access to capital and an enabling permitting regime. At first glance, the EU appears well positioned to establish itself as a laboratory for climate-neutral basic industries; EU locations account for a significant share of the planned investments into breakthrough technologies with drastically reduced emissions. Yet, given the uncertainties around technological and economic feasibility of these new technologies, it remains uncertain whether current investments will materialize, whether they will successfully establish EU leadership, and whether first movers will indeed capture the market.

When it comes to **key clean technologies, EU producers are at risk of losing their competitive advantage** and market share as major competitors are pursuing ambitious industrial policies. There are, however, value chain segments such as PV engineering solutions and services, wind turbine and electrolyser production, where EU companies have a good chance of establishing or maintaining leading market positions. **EU industrial policy therefore needs to focus on exactly those sectors and value chains segments, where it can achieve and defend technological leadership** and thus remain competitive.

EU industrial policy: a broad but patchy mix

The EU's broad industrial policy mix currently consists of a diverse array of policy instruments aimed at tackling various market failures. **However, while there are overarching goals, the EU's policy mix for climate-related industrial policy is a fragmented patchwork of different instruments** that follow divergent logics and aims. Key initiatives like the Net Zero Industry Act are not clearly targeted at specific market failures. All in all, there is little overarching coordination of industrial policy at EU level, but also between the EU institutions and its member states. The resulting gaps and inconsistencies, as well as a lack of ambition and resources, limit the effectiveness of the EU's industrial policy strategy.

A lack of coherence and ambition affects EU-level funding for climate-related industrial policy: First, financial volumes are only moderate, especially compared to investment needs, and to the volumes mobilised elsewhere. Second, existing EU funds lack accessibility and are managed by risk-averse public institutions. Third, while the EU performs comparatively well in R&D spending, there is a large gap in scale-up and deployment support. As a result, the EU gives away its comparative advantage in early-stage clean tech innovation during subsequent steps of the innovation value chain (Draghi, 2024). Finally, the EU relies heavily on subsidies at the Member State level, resulting in efficiency losses and risks of political and economic fragmentation.

What should EU industrial policy look like?

We argue that the EU needs a concerted industrial policy effort to achieve the goals of the Green Deal. The design of industrial policy instruments should adhere to the following principles:

1. **Address specific market failures with targeted instruments:** these include environmental externalities, knowledge spillovers, coordination failures along value chains, information externalities, and imperfection in risk/capital markets. Market failures lead to inefficient economic outcomes, particularly underinvestment in essential climate action activities.
2. **Prioritise industrial policy where it adds value:** The starting point should be technologies where either the EU innovation ecosystem already results in a competitive edge, or where there is a strategic case for domestic manufacturing capacities (Draghi, 2024). The EU should target those sectors, technologies, and value chain segments where it can be a technological leader and where it can harness synergies between industry transition and cleantech support. For both the transformation of incumbent industry and the ramp-up of key clean technologies, we therefore advocate for vertical industrial policy measures rather than horizontal approaches. This implies political decisions about which sectors and value chain segments to keep in the EU, even if at a higher cost, and which ones to let go. In addition to current or future competitiveness in key clean technologies, prioritisation can also reflect aspects such as import dependence and resilience, provided that targets and their hierarchy are clearly defined (see below).
3. **Develop policies that address value chains and market integration:** it needs to consider the entire value chain to identify parts where EU producers are best placed to secure a lead, and needs to consider crucial inputs to these new / reconfigured value chains. In addition to building up production capacities, it needs to address the demand for climate-friendly products (through fiscal policy or other economic incentives, green lead markets, public procurement etc.).
4. **Design and implement support measures at EU level:** Support measures should be designed and, where possible, implemented at EU level to leverage the single market, to reap efficiencies and scale effects, enable competitive allocation of support, and prevent fragmentation.
5. **Allocate support through competitive mechanisms and equip policies with clear conditionalities and sunset clauses:** Support policies should come with clear conditionalities, sunset clauses, and be allocated through competitive mechanisms to ensure an effective risk-sharing between state and private actors, improve efficiency, and prevent subsidy-dependence.
6. **Embed EU industrial policy in a strategy for outreach and diplomacy, bilateral cooperation, and trade:** EU industrial policy should be embedded in an effective outreach and diplomacy strategy. It should also be aligned with trade policy and be designed to comply with WTO rules, to avoid perceptions or allegations of protectionism. Effects on third countries should be considered in instrument design and considered in diplomatic efforts. Supporting third countries that invest in climate-friendly solutions can help to sustain coalitions of like-minded countries with shared interests. But it can also serve to diversify suppliers and reduce geopolitical risks, including through foreign direct investment and transition partnerships (see below).

Climate, competitiveness, security: navigating the industrial policy trilemma

While industrial policy should support the EU's transformation to climate neutrality, it can – and has been invoked to – contribute to broader public policy objectives such as job creation, regional development and social justice. While industrial policy can address multiple overlapping and related objectives, doing so efficiently requires clarity on the objectives that industrial policy should pursue and their hierarchy, in case trade-offs need to be resolved.

Arguably one of the most pertinent areas of overlap is with the objective of increasing the resilience of the EU economy, by reducing its dependence on imports of critical inputs, and addressing security of supply. These objectives have become particularly salient as the EU faces an increasingly hostile geopolitical environment and competition for key clean technologies, most notably through the US IRA and China's industrial policy. The EU's initial response (through the Net Zero Industry Act and the Critical Raw Materials Act) has been to set ambitious targets to reduce import dependencies, diversify supply and reshore production of products that were identified as crucial for the transformation to climate neutrality. This leads straight to the central trade-off: **import substitution with domestic production reduces dependence on imports, but also drives up the costs of key inputs for the energy transition.** This makes investment in clean technologies less favourable and delays the point where they reach cost parity with fossil-based incumbent technologies.

We argue that a more nuanced approach is needed, which pursues import substitution only where it makes sense:

- **Not all concentrations pose security risks:** suppliers of relevant products, in particular in China, have built up substantial production capacities and are under pressure to utilise these capacities. More critical from the EU perspective are instances where foreign suppliers have control over key inputs to the production process (e.g. permanent magnets for wind turbines or EVs) that cannot easily be sourced elsewhere, and which are key for building up domestic production in the EU.
- **Risk assessments need to consider the entire value chain:** there is little benefit in reshoring parts of the value chain (e.g. PV module manufacturing) if the EU remains dependent on imports of key inputs (ingots, wafers). If the EU wants to become more resilient, it needs to control risks along the value chain.
- **Import diversification as an alternative to import substitution with domestic production:** Where there are concentrations of key inputs that are deemed too risky, diversification of supply sources is an alternative to import substitution (reshoring). This includes friendshoring / nearshoring, i.e. helping to build up production capacities strategically in third countries in the European periphery, or in states with whom the EU entertains favourable political and economic relations.

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Abbreviations

CAPEX	Capital expenditure
CBAM	Carbon Border Adjustment Mechanism
CCS	Carbon Capture and Storage
CCU	Carbon Capture and Utilization
CCUS	Carbon Capture, Use and Storage of CO_2
EHB	EU Hydrogen Bank
EPC	Engineering, procurement, and construction
EU	European Union
EV	Electric vehicle
IRA	Inflation Reduction Act
MS	Member State
NZIA	Net-Zero Industry Act
OPEX	Operating Expenditure
PV	Photovoltaic
STEP	Strategic Technologies for Europe Platform
TRL	Technology Readiness Level
WTO	World Trade Organization

1 Introduction

Industrial policy is back in the political discourse. The Covid pandemic and ensuing supply chain disruptions, as well as intensifying geopolitical competition, lead to a reconsideration of the roles of public policy and state intervention in the economy. Moreover, as the European Union pushes to transition to a climate neutral economy, China and the US have supercharged the competition over technological leadership and market shares in key clean technologies, while the EU's energy-intensive industry tries to figure out its place in a climate-neutral economy while remaining competitive.

Across the EU and within EU institutions, there are calls to respond to these challenges. In response to the US' Inflation Reduction Act, the Commission has launched the Green Deal Industrial Plan in 2023, which culminated in the adoption of the Net Zero Industry Act (NZIA). However, across the EU and its Member States, the NZIA is not regarded as an adequate answer to the new industrial policy realities and the EU's structural challenges. Consequently, in the 2024 European Parliament elections, economic competitiveness has emerged as one of the main priorities across the political spectrum, as reflected in the Antwerp Declaration.

The Commission has foreshadowed that more effort will be needed to transform the industrial base of the EU economy. In its 2040 target communication, it stressed that a new and concerted industrial policy effort will be a precondition for the success of the Green Deal and it already hinted at new initiatives in the upcoming legislative cycle that will build on the Green Deal Industrial Plan: "To make the European Green Deal succeed in the next decade, a firmer and renewed European agenda for sustainable industry and competitiveness must complement it now and in the coming years" (European Commission, 2024a, p. 14).

For the new legislative term of the European Commission, Commission president Ursula von der Leyen announced in her political guidelines that the incoming Commission will launch a Clean Industrial Deal within the first 100 days of taking office, as one new element to further develop the European Green Deal. This Clean Industrial Deal is meant to comprise several initiatives, such as an Industrial Decarbonisation Accelerator Act to channel investment into infrastructure and industry, a new European Competitiveness Fund and European lead markets for clean technologies (von der Leyen, 2024). The development of the Clean Industrial Deal will draw on a comprehensive analysis of the future of European Competitiveness, published in September 2024 by the former ECB president and Italian prime minister Mario Draghi at the request of Commission president von der Leyen (Draghi, 2024).

We argue that given this reinforced interest in industrial policy across the EU, there is an urgent need for a clearsighted approach to doing industrial policy. The goal of industrial policy according to Juhász et al. (2023, p. 4) should be to "target the transformation of the structure of economic activity in pursuit of some public goal". As energy-intensive industry in Europe struggles to transform and the position of EU manufacturers for key clean technologies is increasingly contested, we argue that a renewed industrial policy effort is needed that aims to change the structure of the economy in the pursuit of climate-neutrality and competitiveness, and consequently social welfare.

In discussing these issues, this paper focuses on how to leverage industrial policy to make EU industry fit for climate neutrality, reorganising value chains towards a de-fossilised and circular industry. While industrial policy is also increasingly discussed in connection with geopolitical considerations such as defence and security of supply, we initially focus on how EU industrial policy can contributed to, and be aligned with, the transformation to climate neutrality. Chapter 4 then broadens this scope to discuss how geopolitical considerations may or may not be aligned with such a climate-oriented industrial policy. Other aspects of industrial policy – ensuring a supply of skills and labour, harnessing the potentials of digitisation, ramping up the European defence industry and lowering the overall bureaucratic burden – are not the focus of this paper, and only addressed in a marginal way.

This paper sets off by taking stock of the state of transformation and competitiveness in EU industry in the two frontiers of climate-industrial policy: (a) transforming incumbent energy-intensive industries and (b) the clean technology value chains, cleantech in short (chapter 2).

We then explore which principles should guide the design of industrial policy, arguing that it should be targeted at fixing market failures. We analyse the existing EU policy mix focused on the two frontiers by mapping it along the key market failures EU policy must address. Based on this and literature, we develop recommendations for developing the EU's climate-industrial policy mix (chapter 3).

Finally, we consider the trade-offs that exist in pursuing different objectives with industrial policy, such as decarbonisation, competitiveness, or security and specifically the question, whether the EU should support domestic clean manufacturing (chapter 4).

2 The state of the industry transformation and key clean technologies in the EU

With the rise of industrial policy back to the top of the political agenda, three policy angles are often mixed which we argue should at least conceptually be distinguished from one another. The first one is *competitiveness* of the overall economy – the central focus of the Draghi report's findings. Second, industrial policy has been discussed in the context of the *industry transformation*, i.e. the challenge to hoist incumbent, energy-intensive sectors such as steel, cement and chemicals on a path to climate neutrality. Third, industrial policy can refer to the ramp-up of *key clean technologies* that enable a carbon-neutral future, such as solar PV, wind turbines, and electrolysers.

To improve analytical clarity, this work sets a clear focus on the two policy domains of "incumbent fossil industries" and "key clean technologies", and with it our contribution to ongoing debates. Incumbent industries like steel and cement have traditionally represented the backbone of the production economy. At the intersection of climate and industrial policy, their challenges and barriers for a green transformation have been widely discussed. In contrast, upcoming key clean technologies, such as wind, solar, electrolysers, and removal technologies exemplify the EU's commitment to climate action while reaping the benefits of domestic innovation. While both domains contribute towards the economy's overall competitiveness, there are a set of factors – demographics, education and skills, the role of artificial intelligence, just to name a few – that determine the EU's competitiveness in a broader sense yet will not be captured at the core of our analysis.

Until now, debates around incumbent emitting industries and upcoming key clean technologies have largely been siloed in the EU, each being addressed in separate policy debates, economic analyses, and public narratives. Incumbent industries – most notably the basic materials industry as a major source of greenhouse gas emissions – have typically been discussed in the context of preventing (alleged) de-industrialisation and job losses while safeguarding international competitiveness (carbon leakage), while green technologies have been framed within innovation, environmental sustainability, and future growth potentials.

Instead, we argue that these two critical domains should be discussed together, recognising the interconnectedness of their pathways and the need for a joint industrial policy approach. More specifically, we aim to identify policy approaches that unlock synergies between the two domains, eventually accelerating the EU's transition towards climate neutrality. For instance, while traditional industries rely on key clean technologies (providing sufficient green electricity, for example) on their path to decarbonization, key clean technology players hope to find domestic early adopters to accelerate the scale-up of innovative technologies. Through such an integrated discussion, we highlight the need for balanced strategies that manage the transformation of traditional industries while accelerating the adoption of key clean technologies, ensuring an efficient transition for all stakeholders.

2.1 Policy domain 1: Incumbent industry

2.1.1 Past: The EU's industrial strategy as a cornerstone for transformation

Debates on industrial development and competitiveness in the EU have long been driven by fears that ambitious EU climate policy and EU leadership would exacerbate the (perceived) risk of de-industrialisation; this was most prominent in the significant political attention afforded to addressing the carbon leakage risk. At the same time, EU leaders had become cautious about interventionist policies with the declared intention to change the structure of the economy, or to promote national or European champions. While there had been some experience with such "vertical" EU industrial policy going back to the 1950s and 1960s (with Airbus as one notable result), since the 2000s EU policy had pivoted to "horizontal" industrial policy measures, which aim to create favourable conditions for all business across sectors (e.g. through better regulation, lightening the bureaucratic burden, or improved access to capital markets).

During the last years, several developments changed this perception. The announcement of the European Green Deal resolved all doubts (where any had remained) that the EU is serious about its ambition to transform to a climate-neutral economy. The EU ETS reform as part of the fit-for-55 package clarified this further – including the realisation that free allocation of emission allowances (which had primarily benefited industrial emitters) will be contracting further to reach zero in ten years. The pandemic and the energy crisis following Russia's attack on Ukraine, in different ways, both shifted perceptions regarding the role and responsibility of the state and brought with them massive state interventions into the economy – from vaccine development to the manufacturing of personal protective equipment and respirators, strategic stockpiling of energy resources, to temporary nationalisation of airlines or utilities. At the same time, energy-intensive industry has been severely impacted by these crises: Since 2021, production went down by 10-15%, and imports from countries with lower energy cost have been growing steadily (Draghi, 2024). Finally, interventionist industrial policies in the US and China, including massive state support for investment into clean technologies, contributed to the shifting perception of the role of the state, and the renaissance of industrial policy.

Until now, however, European industries have largely been shielded from pressure to transform. EU industry has faced few negative incentives – under the EU's main policy instrument, the EU ETS industrial emitters benefited from free allocation of emission allowances. At the same time, there have been some positive incentives – inter alia, 48 industrial projects (out of a total of 124 projects) have so far been supported from the EU innovation fund with 3.8 billion Euro, or 56% of the EU contribution from the fund (European Commission, n.d.). GHG emissions from the industrial sector have fallen by more than 40% since 1990 – although much of the reduction occurred in the 1990s and 2000s, pace of reduction slowed down markedly in the 2010s. More recently (since 2017), GHG emissions from EU industry have fallen by 2.3% per year on average – where more than 3% would be required to remain on track to climate neutrality by 2050 (European Climate Neutrality Observatory, 2024).

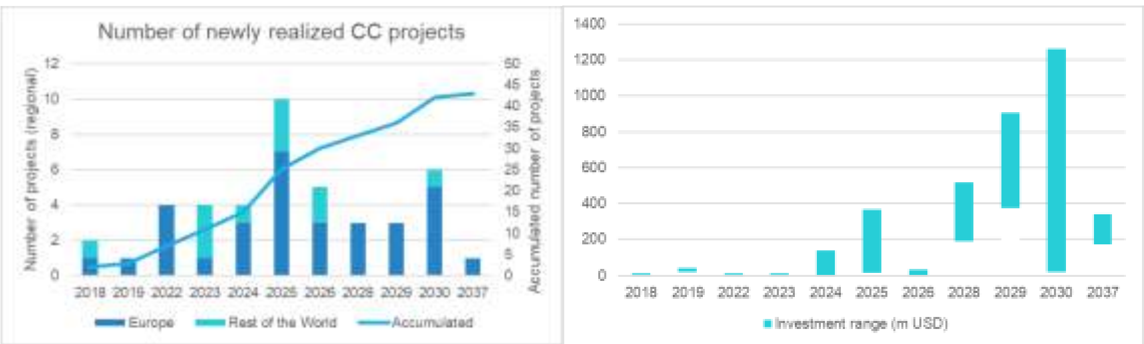
2.1.2 Present: The current status of EU basic materials industries i the transformation to climate neutrality

After energy production, industry is one of the biggest greenhouse gas emitters in Europe (European Environment Agency, 2024). Its transformation, which affects several other sectors downstream the value chain, is therefore crucial to the EU's efforts at reaching climate neutrality. However, factors influencing investment decisions – and with them the respective state of the transformation - differ between sectors.

Cement

Cement producers are reducing their emissions both within existing production routes/processes (e.g. through the use of more energy-efficient plant components or a fuel switch), but above all through the targeted modification of such production routes and individual processes (e.g. raw material substitution towards lower-CO_2 raw materials). Another initiative of the sector is the reduction of emissions in the use of products (e.g. by reducing the cement content in concrete). Options for the use of Carbon Capture and Utilization (CCU) are also currently being discussed intensively in the cement industry (Umweltbundesamt, 2020). According to the Green Cement Technology Tracker (Leadership Group For Industry Transition (Lead-it), n.d.), which collects public announcements of investments in low-carbon cement technologies, Carbon Capture and Storage (CCS) and CCU measures currently comprise around 36 percent of the planned emission reduction levers in the GCCA 2050 Roadmap (Global Cement and Concrete Association (GCCA), 2024). Cement and binders, which include calcined clays, account for 11 percent of the announced reduction measures. As the Green Cement Technology Tracker shows, around 66% of the carbon capture projects announced worldwide will be implemented within the EU. Among the CC projects for which a "Year online" is shown in the data base, the project progression curve (number of projects over time) and the annual investment ranges evolve as follows:

Figure 1 Number of projects and annual investment ranges



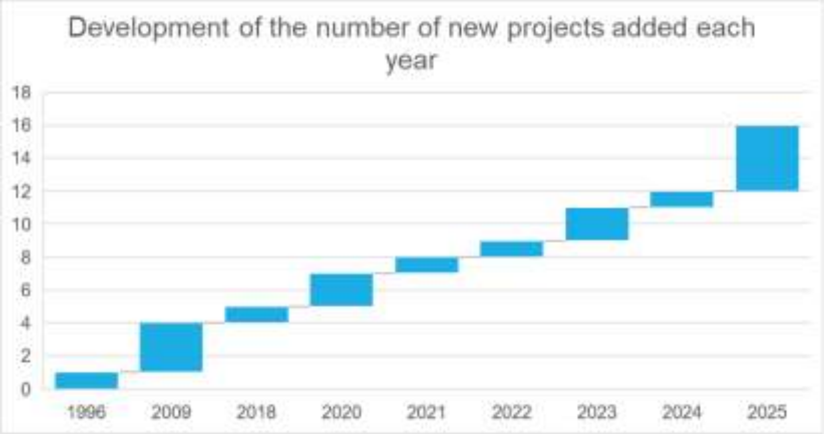
Source: (Leadership Group For Industry Transition (Lead-it), n.d.)

With the exception of 2023, European projects account for the lion's share each year. One project left out of the investment graph is particularly noteworthy here. This is because it represents an incomparably high investment in the CO_2 capture project of the Norwegian cement manufacturer Norcem. The plant in Brevik makes it possible to capture and store carbon dioxide on an industrial scale for the first time. The Norwegian parliament gave the green light for financing in December 2020. The expected start-up costs of the project now amount to around NOK 13.8 billion (USD~ 1,28 billion).

For some of the projects, no specific "year online" is shown in the data set, or the amount of investment associated with the respective project is missing. However, if one calculates an average investment value per project from the stated investment sums (Brevik project excluded) and multiplies this by the total number of announced projects, a total of approx. 6251.878 m USD in investments in carbon capture projects is planned for the period under review.

Among the announcements of technologies for calcined clay kilns to reduce emissions in the cement industry, 45% are on the European continent. Clay Calcination Kilns plants projects are also being implemented in Africa and South America. The status of the projects ranges from the early development stage to "in implementation" and covers everything from the demo or pilot plant to the full-scale project. While the data on investment amounts is very limited, the diagram for the projects for which a "Year online" is shown is as follows (Leadership Group For Industry Transition (Lead-it), n.d.).

Figure 2 Development of the number of new projects added each year



Source: (Leadership Group For Industry Transition (Lead-it), n.d.)

Overall situation: According to the VDZ (German Cement Industry Association), which analyzes a scenario for achieving climate neutrality by 2050 in its roadmap, the industry is reaching the limits of what is technically feasible from today's perspective. The use of breakthrough technologies (e.g. the use of hydrogen or the market launch of CEM VI cements) is just as essential as further increases in efficiency and innovations in the production and use of concrete. Ultimately, however, complete climate neutrality in the cement sector can only be achieved if the capture, use and storage of CO_2 (CCUS) can also be used as an option. Without breakthrough technologies, a maximum reduction of 36% of emissions can be achieved by 2050 compared to 2019 (according to the study's ambitious reference scenario).

Challenges also arise in the raw material mix and through interactions with developments in other sectors. In addition to high costs for the construction and operation of CO_2 capture plants, the industry also sees obstacles in the corresponding infrastructure required for this (both transportation of CO_2 and energy). The availability of renewable energies and efficient power grids, as well as sufficient access to alternative fuels, are just a few examples of obstacles on the path to decarbonization (CEMBUREAU, 2024; VDZ, 2020).

Chemical industry

The relocation of entire production sites to less regulated regions (investment leakage) to maintain the competitiveness can be observed for some value chains, e.g. in the case of ammonia production. While ammonia plants in Europe are being shut down, relocations to the US Gulf Coast can already be observed. BASF and Yara, for example, are investing there in the form of large new production plants for the manufacture of blue ammonia from fossil natural gas. The resulting CO_2 is captured and stored using carbon capture and storage (CCS). According to the feasibility study, the plant in question aims to capture 95% of CO_2 emissions (Göbelbecker, 2023).

In 2023, the European Commission, together with the EU member states of the chemical industry and other interested stakeholders, published the Transition Pathway for the Chemical Industry. The action plan contained therein shows around 190 measures required to successfully implement the transformation of the European chemical industry and its retention within the EU. An annual progress report is also used to monitor the success of the plan. In general, a successful transformation of production often requires completely new processes. These will not be available until the mid-2030s at the earliest. For example, according to the VCI's “Roadmap 2050”, the development of new processes for the production of six important basic chemicals will cost the German chemical industry an additional 45 billion euros over the next few decades. From the mid-2030s, the chemical industry's demand for electricity will therefore increase rapidly. According to the study, a CO2-neutral, electrified chemical industry will consume 628 billion kilowatt hours of green electricity per year - as much as Germany's entire electricity production today. This means that the expansion of wind and solar energy in Germany must be accelerated enormously. The EU Commission is now also tackling this; it therefore wants to increase electricity generation from offshore installations in the sea by a factor of 25 by 2050. However, the price of this electricity also plays a key role here (VCI, 2019).

Steel

Eurofer identifies around 60 low-carbon projects with a Technology Readiness Level (TRL) of 7 or above, i.e. approaching market readiness and commercial deployment. If fully implemented, these projects would reduce the industry's CO_2 emissions by 81.5 million tons per year by 2030. Eurofer estimates that these projects will require investment (CAPEX) and annual operating expenditure (OPEX) of around €85 billion by 2030 (EUROFER, 2024).

The "Green Steel Tracker", a tool from the Leadership Group for Industry (LeadIT), can be used to track the exact status of CO_2 reduction, especially in global steel production. According to the data, mainly R&D partnerships and full-scale projects (Leadership Group For Industry Transition (Lead-it), 2024).

In addition to the availability (expansion of infrastructure) of low-cost, low-carbon energy sources (especially electricity and hydrogen), the successful transformation of the steel industry also requires appropriate regulation with regard to CO_2 transport and storage, as well as a considerate legal framework to protect against carbon leakage (VCI, 2019).

A study for the ITRE Committee of the European Parliament by Sander De Bruyn et al. (2020) shows the available technologies for decarbonizing the chemical, cement, iron and steel and refinery industries as well as the existing financial instruments in the sectors. The document also presents political roadmaps for shaping and promoting the transition to a climate-neutral European industry as part of the Green Deal (Bruyn et al., 2020). In addition to many other technologies that can contribute to the decarbonization of European industry, three measures in particular play a central role according to this study. Specific efficiency measures and the use of CCS can significantly reduce emissions without major changes to process structures.

Replacing fossil fuels with renewable fuels (electrification, green hydrogen, etc.) also has a clear impact on the path to the greenhouse gas neutrality target. Finally, alternative process routes (e.g. using CCU or expanding the circular economy) should always be considered. However, the study also shows that the introduction of these technologies requires a suitable political framework. In addition to investment in renewable power generation and the rapid expansion of infrastructure, this also includes, for example, the provision of public funds to accelerate technology development or an increase in carbon prices.

2.1.3 Stumbling blocks: Transformation as a challenge for the basic materials industry

The task of transformation presents the European economy with a major challenge. At the same time, current conditions (such as the ruling of the German Federal Constitutional Court on the Climate and Transformation Fund) are making the transition to climate-friendly production even more difficult across all sectors. Uncertainty about public support and other uncertainties mean that some urgently needed investments to introduce and implement climate-friendly measures are not being made or are being postponed further. However, support from the state is necessary in many cases, as complex process changes present companies with substantial financial challenges. As a consequence, and due to market failures that we investigate more in detail below, many producers are not able to address these challenges on their own.

The sluggish expansion of the infrastructure is also holding back the industries from using innovative technologies in a timely manner. After the changeover, they are dependent on the reliable and sufficient availability of electricity or hydrogen, for example.

In addition to energy transportation, capacities also play a role in ensuring a sufficient energy supply. Accelerating the expansion of renewable energies is a basic prerequisite for every company's ability to transform. Nevertheless, the decision to convert energy supply to renewable sources also has a financial component. For example, the cost of generating energy from fossil fuels (coal, gas, etc.) is still significantly lower than that of sustainable alternatives. At the same time, the enormous risks associated with the volatility of prices and uncertain supply conditions have become apparent since the Russian attack on Ukraine at the latest. At the same time, investment decisions must be made in a market in which energy prices (despite a series of concessions for industry, e.g. reduced grid fees) are already significantly higher than those of competitors. While the industrial electricity price within the EU will average around €0.203/kwh in 2022 or 2023, American or Chinese companies will only pay around €0.084/kwh (vbw, 2023).Another challenge in the decision to invest in energy or CO2-saving measures is return on investment, which is still too uncertain or not high enough. Even with the expectation of rising carbon prices, even today the cost-intensive transformation to climate-friendly production processes is therefore often not competitive compared to the continued operation of incumbent fossil plants. Opportunities to promote such technologies and to protect companies from less regulated non-European competitors (protection against carbon leakage) are currently on offer (e.g. in the form of free allocation or the implementation of a Carbon Border Adjustment Mechanism (CBAM)), but are often not sufficient. In addition to many other cross-sector barriers on the way to a competitive and climate-neutral basic materials industry, the path to a climate-neutral economy is also characterized by sector-specific obstacles.

As previously described for the cement and steel industries, the maturity of most transformative technologies is often still in its infancy and the promising innovations are not yet ready for the mass market despite the enormous time pressure. Many of the investments flow into demo or pilot projects and not into broad mass production.

The availability of an adequate CCS infrastructure is also a relevant stumbling block, particularly in the cement and chemical industries. Sector-specific regulatory barriers such as cement standards also play a decisive role on the path to industrial decarbonization, making it difficult to disseminate innovative binders.

2.2 Policy domain 2: Key clean technologies

Industry's transition towards climate neutrality hinges on key clean technologies, which enable the transformation of business models and value chains towards climate neutrality. From an industrial policy perspective, this creates opportunities for synergies: If countries manage to establish technology leadership for those technologies, they can both accelerate the domestic transition to climate neutrality and reap the financial (and fiscal) benefits from exporting these technologies.

In this section, we summarise the status quo for a selection of clean technologies that are key for the transition to climate neutrality. In line with the observation that, historically, industrial policy has been targeted at the supply- rather than the demand-side, we focus on *manufacturing capacities* of those technologies as opposed to their *deployment*.[1] At the same time, we acknowledge that (i) the ramp-up of production capacities hinges on strong domestic markets, but (ii) that risks of capacity bottlenecks can become prevalent when the build-up of production facilities does not match demand-side expectations. Hence, wherever available, the current state of deployment is also discussed briefly.

In the following, we compare both manufacturing capacity and deployment for these key clean technologies to the EU's 2030 targets. While we argue this approach gives a first overview of the state of play, it is important to discuss the role of these targets critically. More specifically, we derive the EU's domestic manufacturing capacity targets from the 40% local content target of the NZIA, which was statically set for a wide variety of clean technologies. While for some of these technologies markets are still to be formed at the time of writing, for others such as wind turbines the EU's local content is already much larger than 40% (see below). Against this background, the EU's NZIA targets should be interpreted with caution.

In addition, announced projects will only enter the development pipeline after their final investment decision – i.e. they do not necessarily have to end up being built. While it might look like the EU is on track for meeting its local content targets with the announced projects for some key clean technologies, the distance to target should always be interpreted with this in mind. If a deployment or manufacturing capacity target is therefore met, but a large share of projects counting towards this target has not reached the final investment stage, there are reasons to remain cautious about the EU's achievement of this target in the long run.

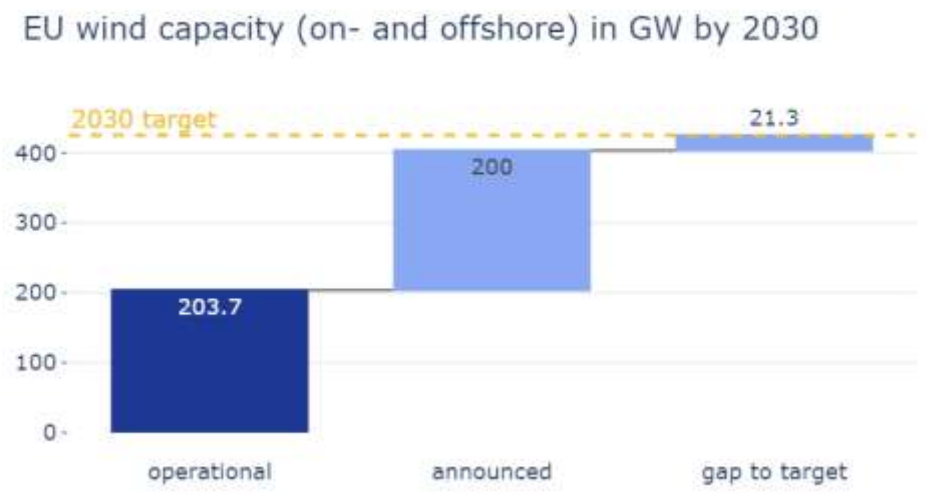
Wind turbines

The manufacturing and deployment of wind turbines in the EU will continue to play a key role in decarbonising the electricity sector. As industrial processes become increasingly electrified, renewable electricity is a key enabler for the EU's green industrial transition.

[1] As we prioritise technologies with a substantial contribution for the industry transition, some examples often mentioned as "green lead technologies" in the literature, such as electric vehicles or batteries, are left out of the picture. Due to our focus on production rather than deployment, we do not consider transport infrastructure for carbon dioxide or hydrogen in this section. For a more detailed overview of the state of manufacturing and deployment of clean tech in the EU see e.g. Bruegel's European clean tech tracker: https://www.bruegel.org/dataset/european-clean-tech-tracker

With the existing capacity and the expected build-out up to 2030, the EU will likely fall short of its REPowerEU wind deployment target of 425 GW (Deloitte, 2023a; Wind Europe, 2024). The vast majority (90%) of the currently installed EU wind capacity is onshore; and it will continue to be so as two thirds of the expected additions will be deployed on land, as well (European Commission, 2023a; Wind Europe, 2024).

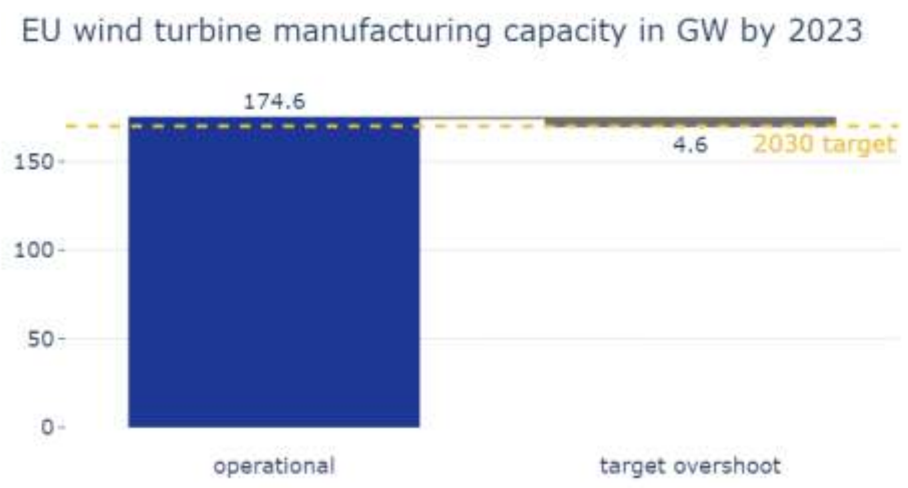
Figure 3 EU on- and offshore wind capacity by 2030



Own visualisation based on IEA (2023a), Wind Europe (2024) and European Commission (2023b)

Barriers in wind energy deployment have exacerbated demand uncertainties for wind turbines, which in turn has put EU producers under pressure recently. Out of the wind capacity deployed in the EU, more than 80% has been produced domestically (European Commission, 2023a). If the industry just manages to produce at current levels, it would therefore stay above the 40% domestic content target of the NZIA already. All in all, the EU wind turbine industry hence seems comparably well-positioned.

Figure 4 EU wind turbine manufacturing capacity by 2023.



Own calculations and visualisation based on IEA (2023a), European Commission (2023a), and European Commission (2022b).

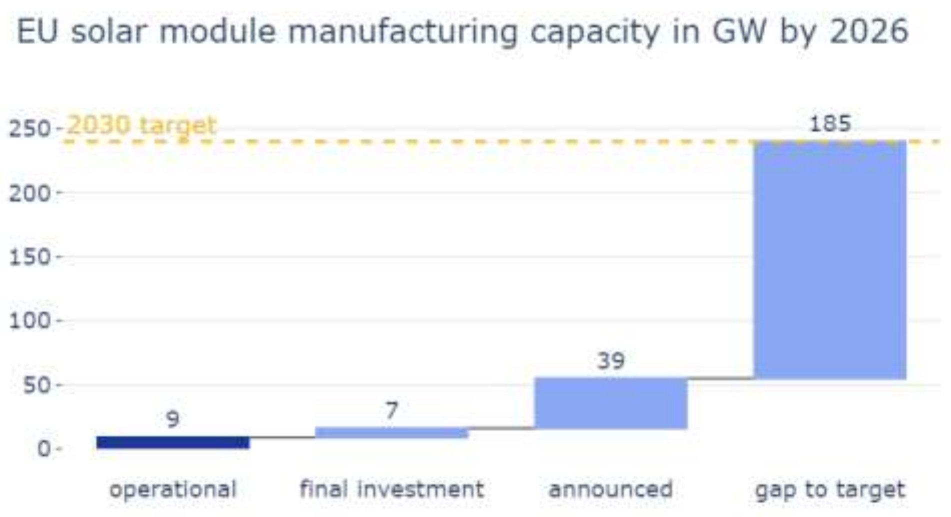
However, the market share of EU-based producers has fallen since 2020, and the EU remains behind its own production targets (Deloitte, 2023a; European Commission, 2023a). On top of uncertainties in turbine demand, access to raw materials and labour shortages have introduced additional challenges for domestic wind turbine production (European Commission, 2023a). As a result, it remains to be seen whether the EU wind industry can continue to contribute the majority of turbines deployed domestically.

Solar PV

Just like wind power, solar photovoltaics (PV) is a critical driver to supply increasingly electrified industrial installations with low-carbon electricity at competitive rates. However, the EU is not on track to meet its solar targets, neither in terms of deployment nor domestic production (Deloitte, 2023a). Following REPowerEU, the EU Commission came forward with a solar strategy, setting a 2030 deployment target of 600 GW (European Commission, 2022a). Currently, only less than half (roughly 260 GW) are installed in the EU (McWilliams, Tagliapietra, et al., 2024), but there is reason for optimism going forward. This is because EU solar deployment has accelerated markedly in recent years, driven by higher electricity prices, falling costs of modules and efforts to become more energy independent following Russia's attack on Ukraine (EurObserv'ER, 2023).

Currently, there is a mismatch between EU solar production targets, publicly announced levels, and actual final investment decisions for production capacities.

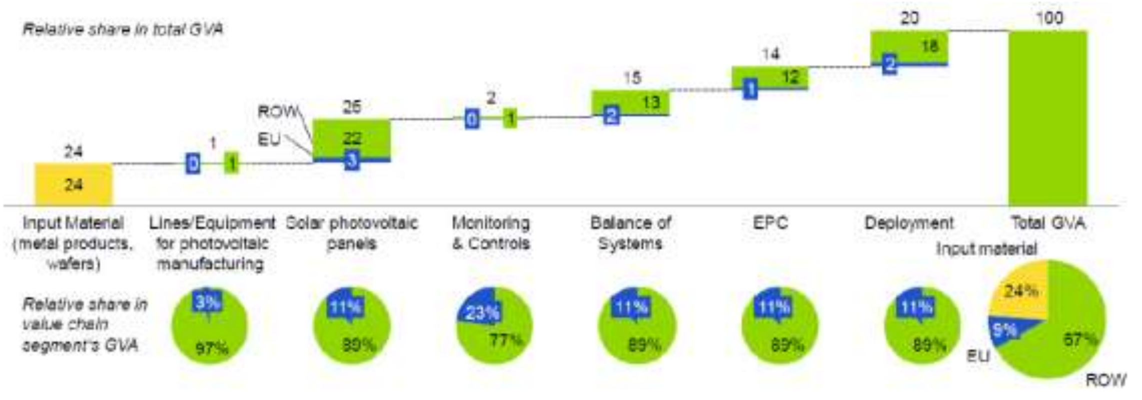
Figure 5 EU solar module manufacturing capacity by 2026



Own visualisation based on McWilliams, Tagliapietra et al. (2024). 2030 target is assumed as 40% local content of the EU's deployment target as per NZIA (European Commission, 2023b).

Consequently, as of today the majority of solar panels deployed in the EU are manufactured in China (European Commission, 2022a; McWilliams, Tagliapietra, et al., 2024). While it has been argued that EU solar production needs to accelerate even more than wind turbine production (Deloitte, 2023a), in the case of PV, the various steps of the supply chain should be differentiated.

Figure 6 Relative shares in Gross Value Added along the solar PV value chain



Source: European Commission (2021)

Figure 6 illustrates that, in addition to the value added from producing solar panels itself, substantial value shares accrue towards the end of the PV supply chain. Rather than pursuing EU market power in subsectors with less value added, policies should therefore be aimed at building a competitive advantage at balance of systems, as well as engineering, procurement, and construction (EPC) solutions. At the same time, the EU should not try to catch up with cost-effective Chinese manufacturers of solar PV panels. Despite substantial value added in this step of the value chain, considerable efforts and funds would be needed to re-gain a competitive edge on panel manufacturing. For example, while the IRA is expected to grow the US solar industry fivefold (EurObserv'ER, 2023), this will likely happen at levels of public support that match or even exceed the overall cost of producing panels in China in the first place (McWilliams, Tagliapietra, et al., 2024).

At the same time, a limited extent of manufacturing capacities could be kept domestically to spur secondary industrial policy effects, for instance through maintaining an industrial base as a foundation for further innovation processes, or to increase supply chain resilience. In these cases, the EU and its member state governments would deliberately bear additional cost to reap such secondary benefits. As a limited manufacturing volume would be sufficient for this approach, however, it would still not require a ramp-up of solar PV module production capacities at full scale.

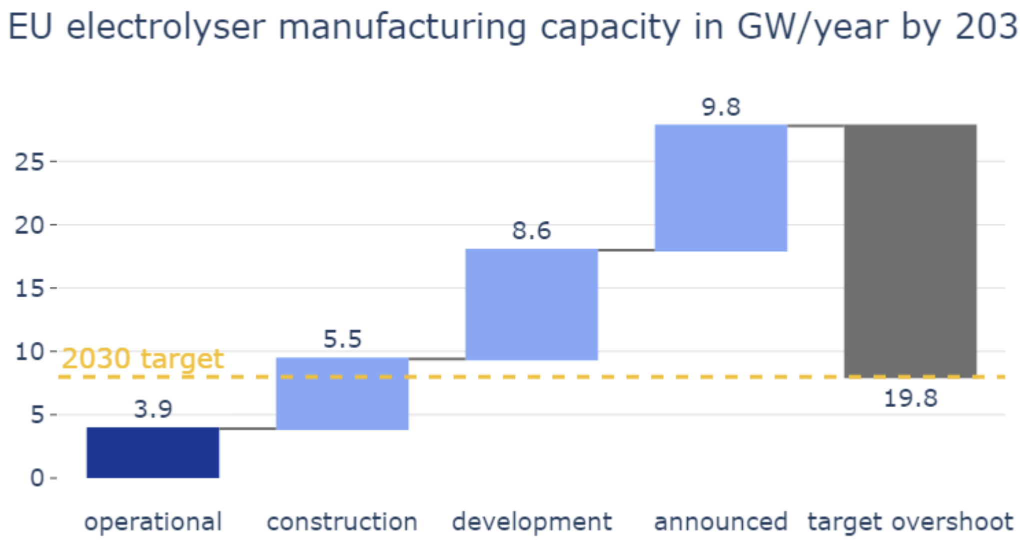
Building on a strong PV innovation ecosystem in the EU, with its solar strategy, the EU Commission has therefore proposed to focus on (i) technology developments in the EU to further improve conversion efficiency and sustainability of modules, (ii) downstream segments of the supply chain, and (iii) strengthening supply chain resilience, for instance by diversifying silicon supply and improving circularity, rather than domestic large-scale production (European Commission, 2022a).

Electrolysers

Green hydrogen (i.e. produced with renewable electricity) has a central role to play for the industry transition – as an energy carrier for high-temperature heat where electrification is not feasible, as a feedstock, and as a reduction agent. Electrolyser deployment in the EU thus needs to take off to enable green processes, particularly to satisfy demand from the EU's steel and ammonia sectors (Hydrogen Europe, 2023). For 2030, the REPowerEU plan sets the goal of 10 million tonnes of renewable hydrogen produced domestically in the EU, and the same quantity of renewable hydrogen imports (European Commission, 2022b). As re-emphasised through the Net Zero Industry Act, that would require 100 GW of EU electrolyser capacity by 2030, 40% of which should be installations “Made in the EU” (European Commission, 2023b).

Electrolyser deployment in the EU has accelerated, for example with a doubling of capacity from 2021 to 2022 (IEA, 2023b). There are around 4 GW of electrolysers currently deployed in the EU, and if producers were to follow through with announced investments, there are good chances that the EU’s targets can be met. Deloitte (2023a, p. 22) estimates that, in order to reach cumulative domestic electrolyser deployment of 100 GW in 2030, annual deployment of around 20 GW would be needed by that year. To reach the EU’s local content target of 40%, 8 GW of annual electrolyser production capacities would hence be required in 2030 – less than the sum of facilities that are operational and under construction today. However, to claim industrial electrolyser leadership with substantial global market shares, much larger capacities will be needed. At the same time, Figure 7 shows that roughly a third of the announcements are still waiting to be developed.

Figure 7 EU electrolyser manufacturing capacity by 2030



Own visualisation based on Hydrogen Europe (2023) and Deloitte (2023a).

All in all, the EU is currently in a strong position and holds the world’s largest electrolyser manufacturing capacities – nevertheless, China has challenged this position with accelerated build-up of production capacity, larger export shares and the ability to produce standard electrolysers at substantially lower cost (Aurora Energy Research, 2023; Deloitte, 2023a). Moreover, against the background of industrial policies abroad such as the IRA, it remains to be seen how the electrolyser capacity will be ramped-up in non-EU regions. For the EU, the ramp-up of domestic hydrogen demand and the provision of transport infrastructure will be crucial in determining the way forward (Aurora Energy Research, 2023). Therefore, at this early stage of hydrogen value chains only being developed, it is still an open question whether the EU can stay on track for both domestic deployment and production targets.

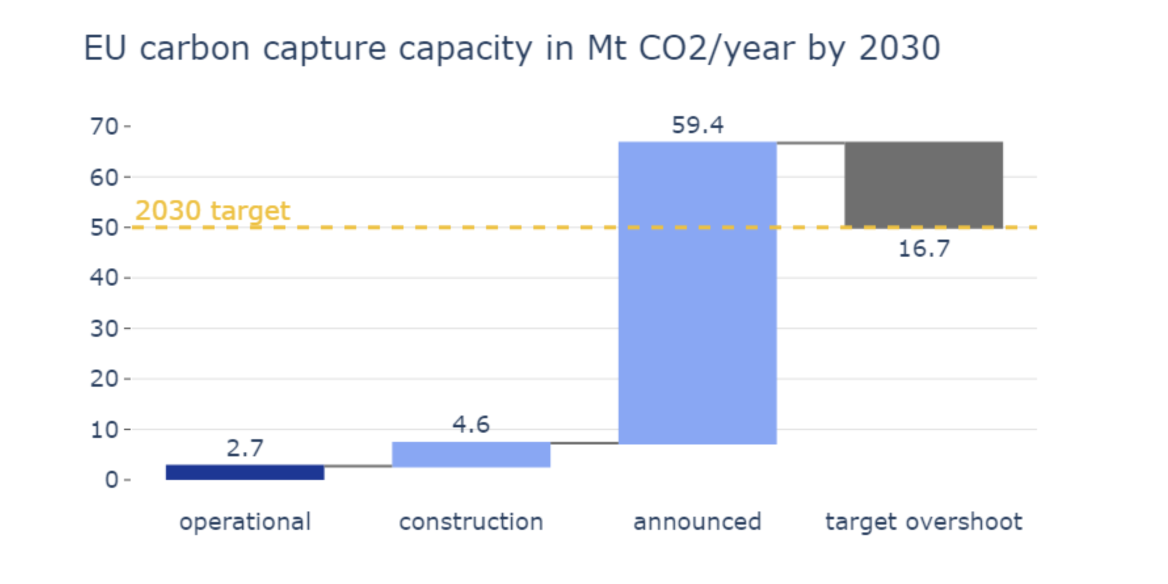
Industrial carbon capture

Carbon capture utilisation and storage (CCUS) will be needed at industrial scale to compensate for residual emissions in hard-to-abate sectors, both immediately at the plant and less immediate re-captures from the atmosphere. For industrial production processes that involve process emissions (i.e. non-combustion), for example like in the cement industry, carbon capture technologies will be needed to make production processes climate-friendly in the first place. In the long run, if governments decide to bring back overshoot emissions from the atmosphere, even larger scales of removals could be required (Lessmann et al., 2024; Sultani et al., 2024). Therefore, both carbon capture installations such as BECCS and CCS solutions in the cement industry, as well as direct air capture technologies play a key role going forward.

With its NZIA, the European Commission has set out an annual injection capacity target of at least 50 million tonnes of CO_2 by 2030 (European Commission, 2023b). While the NZIA is mostly targeted at the downstream end of the CCS value chain, it is to expect that similar volumes of CO_2 would have to be captured upstream of this value chain.

As of today, still less than 3 Mt of CO_2 are captured in Europe per year (IEA, 2024a). The next years will be crucial in determining the domestic deployment path for industrial removals, but if – and only if – the majority of planned projects were to go ahead, it looks like the EU would meet this goal conveniently.

Figure 8 EU carbon capture capacity by 2030



Own visualisation based on IEA (2024a) and NZIA carbon capture target (2023b).

As tangible policy incentives are still in the scale-up process, voluntary carbon markets have created initial demand for removals. Projects for those markets are taking off in the EU and have reached a count comparable to the United States at least for novel removals (Smith et al., 2024). However, the overall removal share of global voluntary carbon markets is currently still dominated by the US (CDR.fyi, 2024).

In the United States, tax credits as part of the IRA have been widely cited as flagship policy for the ramp-up of industrial removals (Manhart, 2024). Nevertheless, the IRA fosters deployment rather than domestic production of removal facilities, which is why it does not necessarily have to lead to a ramp-up of production capacities in the United States. Moreover, just like with any other technology supported through the IRA, the question of overall economic efficiency remains to be answered. In that sense, it can be worthwhile for the EU to focus its industrial policy endeavours on innovation and the build-up of production capacities. This is especially because more sophisticated removal facilities like DACCS plants are more comparable to wind turbines in terms of technological complexity; there consequently is a good chance that production spillovers will play a smaller role than for more standardised products such as PV modules (Malhotra & Schmidt, 2020).

Therefore, in the long run, if the EU plays its cards right, its global role for industrial removals will lie in the supply of engineering solutions and services rather than mass deployment (BCG and DVNE, 2024). This is because deployment conditions, such as space and access to cost-effective renewable energy, are more favourable in other regions. Although the market is still nascent and it is difficult to assess a region's competitive edge, the innovation ecosystem in the EU seems to be able to keep up with the United States and China (Smith et al., 2024). Specifically in the case of Direct Air Capture, most plants in operation today are located within the EU as one of the market leaders, the Swiss company Climeworks, has rolled out pilots in Germany, Italy, and the Netherlands (IEA, 2022).

2.3 Summary and outlook

While its leadership is contested, **EU industry has its strengths in both domains of industrial transformation**: building up key clean technologies and the value chains that support them – as well as transitioning incumbent industries (esp. basic industries) on the road to climate neutrality. As a region with a strong industrial base and both physical and knowledge infrastructure, EU industrial policy should coordinate efforts in both domains. Given that other world regions are better positioned in terms of energy and labour costs or renewable resources, EU industrial policy needs to focus on those sectors, and those parts of value chains, where it can achieve and defend technological leadership and thus remain competitive.

Incumbents in basic material industries have accepted the need to transition their technological and asset base, and to some extent their business models, to remain competitive in a defossilised, climate-neutral economy. Increasingly, companies have developed strategies for the transformation, and (particularly in steel) have begun to put them into practice. The successful implementation of these strategies, however, depends on preconditions beyond the control of individual companies: this concerns the availability and costs of infrastructure (electricity, H2, carbon), the supply of renewable electricity and its cost, access to capital and an enabling permitting regime.

At first glance, the EU appears well positioned to establish itself as a laboratory for climate-neutral basic industries; EU locations account for a significant share of the planned investments into breakthrough technologies with drastically reduced emissions. Yet, given the uncertainties around technological and economic feasibility of these new technologies, it remains uncertain whether current investments will materialize, whether they will successfully establish EU leadership, and whether first movers will indeed capture the market. Alternatively, 2^{nd} or 3^{rd} movers could be in a better position by benefiting from the experiences made by others, and by learning from their mistakes.

To assess the landscape of clean technologies and the EU's competitive edge, **it is necessary to look at a more granular level than entire sectors or broad technologies**, and instead distinguish between deployment and manufacturing, but also to investigate different segments of technologies' value chains.

For key clean technologies, experience from the PV supply chain suggests that the EU's strength lies in supplying engineering solutions and services. For a mass production of standardised, low to mid-tech products such as solar PV modules, however, the EU does not have favourable conditions. In this area, the lead established by Chinese producers will be difficult if not impossible to overcome. Similarly, many locations outside the EU offer better deployment conditions for key clean technologies such as solar PV, electrolysers and direct air capture: in some countries, renewable resources such as sun, wind and water are more readily available, regulatory regimes and permitting is easier in others, and yet others (in particular the US and China) encourage the deployment of such technologies with generous financial incentives. As a result, the EU will rarely be the most attractive location.

From our initial assessment, the EU is still rather well-positioned for the manufacturing of wind turbine components, for electrolysers and potentially for industrial removal solutions. Nevertheless, further measures are needed to strengthen the EU's innovation ecosystem, to defend the competitive edge of EU producers and to also reap the future benefits of producing key clean technologies. This is especially pressing for the manufacturing of wind turbines, where EU producers currently are at risk of losing their competitive advantage as manufacturers from other world regions are catching up. Other technologies, in particular solar PV, are far advanced along the learning curve, so that future efficiency gains may rather be obtained from sheer scale. For these, building up large domestic manufacturing capacities appears to be a battle that the EU can only lose – requiring indefinite subsidies and/or strong trade protection measures, and at the cost of driving up the cost of these technologies, and slowing their diffusion. In addition, substantial global overcapacities for mass products such as PV modules and batteries are expected by 2030 (Draghi, 2024). Additional manufacturing investments now therefore bear the risk of asset stranding.

Beyond the analysis given in this section, the outlook for both policy domains – industry transition and key clean tech – provides us with several points to consider when discussing a coherent industrial policy strategy for the EU. First, we have shown that the distribution of skills and technology competences in the EU call for a stronger focus on supporting specific value chains. This may also involve a re-organisation of industrial value chains, where energy-intensive steps move to regions with abundant supply of cheap green electricity. Like this, domestic firms can reap cost-saving potentials without moving facilities outside of the EU. Policies should facilitate such new economic geographies of decarbonisation (Zachmann and McWilliams, 2021) instead of subsidising against them.

Second, the potential for more circular production and business models is far from realized. It can be an additional enabler both for the transition of basic industries (EAF steel, circular carbon in chemicals, circularity in building and construction), but also for the growth of key cleantech (circularity as a way to overcome resource constraints, e.g. in batteries or wind turbines). Moreover, circularity can itself become a new business model, for instance in the case of circular carbon.

Third, we have shown that for some technologies like solar PV module production there is little value in chasing global leaders and re-establishing large-scale capacities at public cost. For those technologies, other strategies appear more effective to build up resilient yet cost-effective supply chains. As will be discussed further in chapter 4, these may include diversifying suppliers and "friendshoring", maintaining a limited industrial base to support further R&D and as an insurance in case of massive and prolonged trade disruptions, or building up a strategic stockpile of key inputs.

In terms of the current policy architecture, the EU's leading role in climate policy ambition has created momentum for the transition towards climate neutrality, including the manufacturers that are to be part of this transition. When it comes to industrial policy instruments, however, a more targeted and strategic approach is required going forward. Roads taken in other parts of the world (the US and China in particular) may serve as inspiration or benchmark for EU efforts but cannot be copied directly. To begin with, the EU's climate policy mix is centred around a strong ETS to drive emission reductions in a cost-effective way, while other regions, and specifically the US, have relied on subsidy-driven policies to ramp up domestic manufacturing capabilities for clean technologies and to stimulate their deployment. However, such approaches are rather geared at quick and visible changes, and design more to create a favourable political economy than to identify and implement the most cost-effective way forward. The downsides to this approach are that domestic industries may require ongoing trade protection measures, that market signals for deployment of key clean technologies are not as effective as they could be, and that their deployment is slowed down as those technologies reach cost parity (and later cost advantages) with current, fossil-based technologies at a later point in time.

Lastly, a successful industrial policy strategy needs to jointly address the transformation of the incumbent basic materials industry and the ramp-up of key clean technologies and pursue synergies between them. First and foremost, lowering cost of renewable energy is critical for EU industry's competitiveness (Draghi, 2024). Cost-effective deployment of solar PV, wind turbines and electrolysers should therefore remain a priority. More specifically, several key clean technologies will also be crucial for the defossilisation of basic industries: direct or indirect electrification of process heat in the chemical industry requires a reliable and cost-competitive supply with renewable electricity, scaling up green hydrogen is an enabler for the transition to green steel, but also as a feedstock or fuel in the chemical industry, and a climate-neutral cement sector will require carbon capture mature technologies and supporting infrastructure. For every supply chain, however, a strategic choice needs to be taken to balance strategic autonomy and security of supply with cost-effectiveness. This is considered more in detail in the following sections.

3 Taking Stock of the EU's industrial policy toolkit

The EU Green Deal aims to "transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use." Accordingly, we argue that the EU's industrial policy should promote the transformation of the EU economy towards these goals. But as we describe in the previous section, current trends are only partly aligned with this. vision of a climate-neutral and resource-efficient economy: for several key technologies that would define competitiveness in such an economy, the EU is at risk at losing its competitive advantage. This applies both to cleantech sectors, but also to the transformation of incumbent industries, as major competitors are pursuing ambitious industrial policies (ESABCC, 2024; European Commission, 2023c; Kögel et al., 2024).

Market failures justify industrial policy (Cherif et al., 2022; Juhász et al., 2023) and we argue that the EU needs a concerted industrial policy effort to achieve the goals of the European Green Deal. Commission President-elect Ursula von der Leyen announced that the new Commission will develop a "Clean Industrial Deal for competitive industries and quality jobs in the first 100 days of the mandate" (von der Leyen, 2024). However, there yet is little clarity on what this Deal will include and how it connects to existing initiatives, such as the European Green Deal, the Green Deal Industrial Plan, or the EU's Industrial Strategy. More so, EU policymaking lacks a clear idea for what constitutes good industrial policy, what sectors it should target, what instruments it should use, what principles it should follow and how it should be embedded in the wider mix of EU climate policy instruments.

We aim to provide such clarity by identifying relevant market failures that EU industrial policy should seek to address and by investigating to what extent the EU's existing policy instruments for climate and industrial policy is geared at these market failures. As a consequence of the market failure approach taken, this section broadens the scope of the study by touching several points considering overall competitiveness as well. Nevertheless, we aim to keep our main focus on the industry transformation and key clean tech. Based on this stocktake of the EU's instrument mix and existing literature, we develop principles for the EU's industrial policy mix, the selection of instruments and their design.

3.1 Climate-oriented industrial policy to address prevalent market failures

Market failures lead to inefficient economic outcomes. Conversely, remedying market failures can improve the allocation of resources and thereby enhance overall welfare (Cherif et al., 2022; Juhász et al., 2023). Concretely, market failures can lead to underinvestment in activities and assets needed for climate action[2], such as the deployment of key clean technologies, research in low-emission production technologies, or electrification of process heat (Armitage et al., 2023; Stern et al., 2022). For climate-oriented industrial policy that seeks to improve the efficiency of resource allocation, correcting this should be the prime justification and objective.[3]

[2] As Stern and Stiglitz point out, the opposite – overinvestment – is theoretically also possible. However, given the many market failures that are biased towards more not less climate actions, we describe in this section, this is unlikely to be the case.

[3] Cherif et al. (2022) suggest that any interventions should pass a cost-benefit test and not be resolved through a better definition of property rights. However, Juhász et al. (2023) argue that this may be difficult in practice as the location and magnitude of externalities may be unknown ex ante, and temporal lags and spillover effects make estimating benefits difficult.

Beyond climate protection, clearly there are plenty other public goals such as national security, social justice, or strategic autonomy, that do not narrowly fit into an efficiency-focused framework (Juhász et al., 2023). Pursuing such objectives can lead to complementarities and trade-offs - in chapter 4, we consider the case for interventions that enhance resilience and security of supply, and thereby depart from a strictly market-fixing approach.

Table 1 summarises the main market failures relevant for the transition to a climate-neutral economy, based on the work by Stern and Stiglitz (2022), Criscuolo et al. (2022), Vollebergh and van der Werf (2023), and Löfgren and Rootzén (2021). Across the EU, these market failures differ in relevance and form, depending on the exact policy framework in the respective member states and the sector in question.

Table 1 Overview of market failures that impair climate action and technological change

Market Failure	Description
Environmental externalities	Negative externality due to underpriced or unpriced GHG emissions as well as social cost of other environmental damages. In the EU, despite increases, the carbon price remains below estimates of the social cost of carbon or estimated economic damages of air pollution and GHG.
Knowledge spillovers and first-mover disadvantage	Generated knowledge cannot be fully appropriated by firms due to spillovers in (a) *RD&D investment*, and (b) *innovative production*. *Spillovers in RD&D* occur since, even with intellectual property rights in place, new knowledge and technological know-how can never be fully protected, leading to underinvestment in private RD&D, for example, in low-emission technologies. *Spillovers in production* can lead to first-mover disadvantages because firms cannot fully internalise productivity, innovation, or knowledge benefits acquired during production, leading to sub-optimal allocation of resources to novel sectors/technologies.
Coordination failures	Coordination failures occur along the value chain, for instance where network effects require the coordination of different actors at different points in a value chain, but the market fails to deliver such coordination. A notable example for coordination failures is the deployment of renewable hydrogen production, which requires infrastructure to be in place as well as predictable demand and business models for suppliers. An example for the chicken-and-egg problem is the adoption of electric vehicles (EVs) and the presence of charging infrastructure (Li et al., 2017).
Information externalities	Imperfect information or information asymmetries, inter alia about new technologies and their costs, emissions content, climate risks, lead to adverse selection, hidden-action problems, or principal agent problems. Such asymmetries exist between businesses along the value chain, between businesses and regulators, and towards private households and consumers. For example, lacking awareness and information about the future carbon price may lead to sub-optimal adoption of emission-saving technologies by households and industry. Businesses have better information about the cost of emission-saving technologies, but also a strategic incentive to exaggerate these towards the regulator.
Imperfection in risk/capital markets	Lack of access to capital; inability to hedge technology or market risks; incomplete information about risk, etc. Missing long-term contracts in power markets, for example, means investors are left with uninsured risk, leading to underinvestment in clean energy (Dimanchev et al., 2024).

To see how these market failures are relevant in the EU context for the transition to a climate-neutral industry, two examples are illustrative: the coordination failures along the steel-hydrogen value chain as well as the lacking access to capital for the adoption of climate innovations.

- First, **coordination failures along value chains are a major barrier for investments in low-emission processes and renewable hydrogen**. For the decarbonisation of the steel sector, renewable hydrogen plays a pivotal role, as the abatement option with the highest abatement potential in primary steelmaking is the switch from blast furnaces to the direct reduction route using (green) hydrogen as reduction agent (Agora Energiewende & Wuppertal Institut, 2020). However, this process switch requires large investments, which are contingent on certainty about the availability and costs of inputs. The primary determinant for the cost of low-emission steel is the cost of hydrogen (Somers, 2022). But the future cost and availability of green hydrogen, produced with renewable electricity, is uncertain. At the same time, investments in hydrogen production depend on demand expectations. This creates a situation where the suppliers of hydrogen may be cautious to invest in the absence of predictable demand and a clear business case, while the potential buyers may be hesitant to switch processes given large uncertainties about hydrogen supply and costs.
- Second, **access to capital is a major constraint for introducing climate innovation**. According to a recent EIB survey on climate innovations, 49% of start-ups and 39% of established firms reported that access to finance is a major constraint to the adoption of innovations meant to generate an environmental impact in their own company or for their end-customers (EIB, 2022). Notably, this survey was conducted in 2020, i.e., at a time when interest was lower across most of Europe. The survey results underline the importance of accessible funding for change to take place. Yet the various market failures above all have a similar effect on the ration between costs and returns of investments: they all either add to costs or mean that the (private) returns are lower or less certain than they should be. In this way, underpriced GHG emissions, information externalities, and capital market imperfections all result in inflated capital costs and make access to finance more complicated.

The presence of several overlapping market failures requires a blend of interventions to address them. Stern and Stiglitz (2022) criticise that a narrow focus on the emission externality that is prevalent in much policy analysis ignores the many overlapping market failures, which may lead to wrong policy conclusions. For example, while carbon pricing centrally tackles the emission externality and is essential for climate action, it does little to remedy market failures related to the public good character of knowledge that result in first-mover disadvantages or underinvestment in research and development.

As we demonstrate in the next section, the EU already employs a rich mix of policy instruments that seeks to address several market failures. However, gaps, incoherences, and ambition undermine the effectiveness of its industrial policy approach.

3.2 The EU has a broad, but patchy policy mix

In this section, we take stock of the EU's climate-industrial policy mix. According to Vollebergh and van der Werf (2023), policy instruments should be targeted at market failures and "the shortcomings of the system that produce the unsatisfactory results in the status quo." Describing which policy instruments seek to address what market failures is therefore a productive first step towards improving the policy mix. We therefore map the different measures and instruments to the market failures described in the previous section and identify gaps and shortcomings. Our focus is twofold: instruments that target the transformation of incumbent industries (directly or indirectly), and those aiming to foster the development of the cleantech industry.

This focus leaves aside other policy domains, such as trade or monetary policy, that may be regarded as part of industrial policy in a wider understanding because they influence important factors such as competition or credit availability. This is primarily a choice to keep the complexity limited: rather than a full evaluation of the EU's industrial policy, the intention is to identify main elements of the EU's policy mix for climate-related industrial policy and derive relevant insights for policy and research.

EU industrial policy: a patchwork of instruments and initiatives

Overall, the EU has a large suite of instruments and measures that can be classified as part of an industrial strategy, aiming to induce technological change towards a climate-friendly economy. Most of them are motivated by apparent market failures. At the same time, neither are all market failures sufficiently addressed nor do all instruments address the specific market failure comprehensively and efficiently. Table 2 maps the EU's core industrial policy instruments onto the apparent market failures they (explicitly or implicitly) seek to address. Notably, the most prominent industrial policy initiatives such as the Circular Economy Action Plan, the Green Deal Industrial Plan, or legislation such as the NZIA bundle different policy instruments and are therefore not listed as individual policies. Their core elements, such as the product requirements in the Ecodesign for Sustainable Products Regulation are included in the overview, however.

Table 2 The EU's Industrial Policy Mix and Market Failures

Instrument / fund / programme	Environmental exter-nalities	RD&D	First-mover disad-vantage	Coordination failures	Information	Imperfection in risk/capital markets
Carbon Pricing						
EU ETS	Dark grey					
CBAM	Dark grey					
Funding						
Recovery and Resilience Facility (RRF)	Light grey	Light grey	Light grey	Light grey		Light grey
Hydrogen Bank				Dark grey	Light grey	Light grey
Horizon Europe (Pillar II)		Dark grey				
Innovation Fund	Light grey	Dark grey	Light grey			Dark grey
IPCEI				Light grey		Light grey
InvestEU Sustainable Infrastructure			Light grey	Dark grey		Dark grey
European Innovation Council		Dark grey	Dark grey			Dark grey
Projects of Common Interest - Connecting Europe Facility				Dark grey		Light grey
Loosening of State Aid rules (TCTF and GBER)						
Informational Instruments						
Taxonomy					Dark grey	Light grey
Labelling requirements (ESPR, BR, CPR, EPBD)					Dark grey	
Standards						
Product Requirements (ESPR, Batteries Regulation, CPR)	Dark grey		Light grey		Light grey	
Emission Standards for Vehicles	Dark grey				Light grey	
Public Procurement (NZIA, CPR, CVD)	Dark grey					

Note: Own illustration. Dark grey shading indicates that the instrument central intention is to correct the market failure in question. Ligh grey shading indicates that the instrument is contributes to addressing the market failure as a secondary objective or a side-effect. TCTF = Temporary Crisis and Transition Framwork; GBER = General Block Exemption Regulation; ESPR = Ecodesign for Sustainable Products Regulation; BR = Batteries Regulation; CPR = Construction Products Regulation; EPBD = Energy Performance of Buildings Directive; NZIA = Net Zero Industry Act; CVD = Clean Vehicles Directive).

The EU's climate-industrial policy target a range of outcomes and market failures. Some instruments are clearly motivated by climate and environmental externalities, such as the EU ETS or the emissions standards for vehicles. Others more clearly target research and development, such as Horizon Europe, while other measures aim to overcome coordination issues by delivering specific outcomes in the energy system, such as the energy infrastructure projects funded via the Connecting Europe Facility. Overall, one can see a clear ambition to mainstream climate action and the energy transition in industrial policy actions.

While EU climate-related industrial policy is guided by overarching goals, the actual policy mix is a patchwork of different instruments that follow divergent logics and aims. Instruments and policies tend to be a product of the EU's institutional constraints and were often introduced as an immediate response to acute crises, rather than resulting from strategic foresight and planning. This becomes clear when considering the policy initiatives of the past four years: The von der Leyen Commission initially introduced the European Green Deal as the broad and overarching narrative combining climate and environment goals with a broader concept of a just and inclusive economic transformation, and launched a suite of coordinated initiatives, including a Green Deal Investment Plan and many pieces of legislation, above all the Fit-for-55 package. However, since the launch of the EGD, other initiatives complemented and supplanted the original package. These were not part of the original design of the EGD but rather added in response to immediate crises, among them the Recovery and Resilience Facility (the single-biggest public climate investment facility in the EU), RePowerEU, as well as the Green Deal Industrial Plan. Also, the latest EU initiatives touted explicitly as "industrial policy", such as the Net Zero Industry Act, do not seem to be geared at correcting any apparent market failures. Instead, they primarily aim to diversify supply chains and support EU cleantech manufacturing, incentivising more EU production. In sum, EU industrial policy is mostly comprised of ad hoc responses to external and internal shocks, coming on top of long-term policy planning.

There is not only little coordination of industrial policy at the EU level, but more coordination is also needed between the EU and member states. There are multiple framework initiatives that may be argued to guide EU industrial policy such as the Circular Economy Action Plan, the Net-Zero Industry Act, or the Green Deal Industrial Plan. In addition, there are the various funds, or sectoral initiatives. However, the governance of the EU's industrial policy remains unclear – also evidenced by the fact that a range of Commission DGs and executive agencies are involved in its implementation.

Fiscal policy instruments are notably absent from the EU's industrial policy mix. This stands in stark contrast to the USA, which, in its IRA, uses fiscal policy instruments such as tax credits extensively. Obviously, this a well-known situation in EU policy making, as key member states (continue to) oppose European fiscal integration. Member states themselves may use fiscal policy in support of industrial policy aims (within the confines of state aid rules). But EU industrial policy is constrained substantially since the EU cannot make use of a central – and comparatively simple – instrument.

Few instruments in the EU's policy mix focus on addressing first-mover-disadvantages, or what is sometimes referred to as the valley of death (Grubb et al., 2021; Humphreys, 2023). This is a primary challenge for large-scale investments in new production processes, as well as for the scale-up of cleantech. The availability of venture capital is comparatively bad in the EU and many startups and SME's cite costs and the availability of finance as the primary constraints for investing in innovations and new processes (European Investment Bank, 2021b). Given this assessment, there is a critical need for the EU to improve its support for the scale-up of innovations.

Considering the specific challenges to industry transition highlighted above (electricity prices, availability of inputs, cost of capital), there is no substantial effort to strategically support the competitiveness of whole industries or sectors. The EU's effort to accelerate the energy transition, improve the integration of energy markets, and increase interconnection will all contribute to lowering electricity costs. But still, the EU is generally very cautious in the direct support of specific industries and firms – not just at EU level, but also in MS through strict state aid rules.

Several measures address environmental externalities, but additional action is justified

Many instruments in the EU's policy mix focus on environmental externalities. With the EU ETS and the forthcoming ETS2 for non-EU-ETS combustion emissions (primarily road transport and buildings), the core policy instruments focus are designed to correct the market failure by internalising the external costs of emissions. With CBAM and the phase-out of free allocation, the EU moreover moves towards fully passing on these incentives to industry. However, additional interventions are justified for two reasons. First, EUA prices were relatively low and persist to be too low to justify investments in deep decarbonisation, especially given long-term uncertainties about carbon prices (Richstein & Neuhoff, 2022). In addition, marginal abatement cost curves are discontinuous, i.e., deep decarbonisation requires non-incremental technological changes (Löfgren & Rootzén, 2021). This justifies additional measures that address the emission externality, such as the variety of standards and product requirements, that direct technological change.[4] Second, as can be seen in Table 2, the EU's carbon pricing policies do not address (and are not intended to address) market failures other than the emission externality. Even if the ETS fully addressed the emission externality, these other market failures would still lead to underinvestment in the transition. Consequently, additional instruments may be cost-effective and lead to more efficient outcomes (Stern et al., 2022).

Although the use of product requirements will only be phased-in in the medium term, recent legislative changes expand the use of labelling to more product categories, including batteries and construction products. This will help to remedy information externalities in these product markets and is a crucial enabling condition for introducing other policy instruments, such as carbon product requirements or green lead markets. These can further contribute to creating demand for low-emission and circular products and thereby reduce market risks.

EU innovation and investments: low volumes, uncoordinated, and too little at EU level

There are many different funds in the EU that provide innovation support, infrastructure development, and other public investments. But there are four apparent problems with the EU's funds and financial instruments. These are explained in the following:

Financial volumes are only moderate, especially compared to investment needs.

The EU has a large suite of funding instruments. However, many of these are relatively small, distributing only several million Euros every year. The EU Innovation Fund is the largest single fund for low-emission innovation in the EU, with an annual size of €3.1 billion in 2023 dedicated to the demonstration of low-emission innovation. With additional funds such as Horizon Europe funds dedicated to industry transition and climate or the European Innovation Council, this adds up to about €10 billion in 2023. While this is substantial and complemented by MS level funding, it pales in comparison to annual investment needs. According to the EU Commission (2024b), reaching EU climate targets requires annual investments of about €1241 billion until 2030 and even more thereafter.[5] The majority will be private investments, but still the EIB (2021a) estimates that about 25% of investments will be public, whereas Pisani-Ferry and Mahfouz (2023) or Baccianti (2022) estimate an even larger share of 50% public investments.

[4] An additional justification for standards such as minimum recycled content requirements is the need to transition to a circular economy, which the carbon price does not directly incentivise. Here, standards can direct technological change towards circularity. However, while recent changes to the ESPR, the CPR or the Batteries Regulation have laid the basis for such standards, they are not operational yet and still to be developed by the European Commission in delegated and implementing acts.

[5] I4CE, a think-tank, puts the investment deficit at €406 billion across just 22 clean technologies (Calipel et al., 2024).

If one looks at concrete EU industrial policy targets, the limited size of funds becomes apparent. The EU's Hydrogen Strategy foresees an annual production target of about 10 million tonnes (Mt) of renewable hydrogen by 2030. The European Hydrogen Bank (EHB) is endowed with €3 billion. Assuming the Bank can fund as efficiently as in its first auction round in 2024, McWilliams and Kneebone (2024) estimates that the EHB's volume should translate into annual production of around 0.7 Mt of renewable hydrogen by 2030. While not all hydrogen development will require support, it will be difficult to meet deployment targets with such modest support.

Existing EU funds lack accessibility and are designed to spend in a risk-averse way.

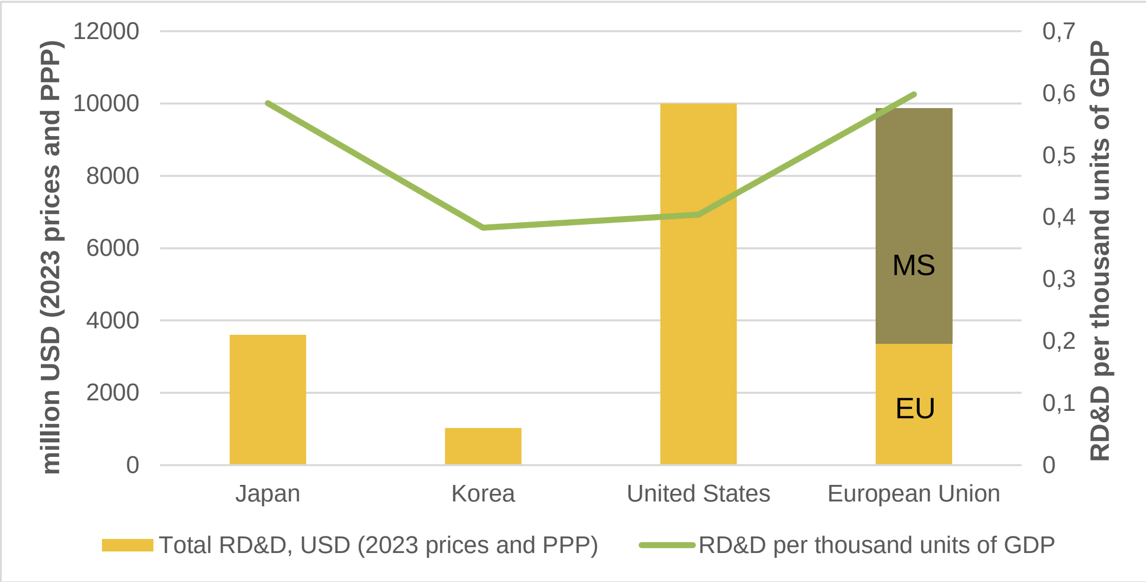
Pinkus et al. (2024) note two shortcomings with EU programmes: a bias to avoid failures and thus against risk-taking, and the fact that Commission services, who manage the programmes, lack the mandate and independence to terminate unsuccessful projects and adapt them flexibly according to developments and needs. Moreover, experience with the Innovation Fund has shown that startups and SMEs struggle to access it, because of the complex application process. Most grants of the IF were awarded to large companies, who tend to have less financing constraints than SMEs and startups. To this end, EU innovation funding must become more accessible on the one hand, and conducive to risk-taking on the other. To achieve this, Pinkus et al (2024), suggest emulating the US ARPA, and creating an autonomous EU agency that mirrors its principles, governance, and management, thus taking more risks and actively managing projects.

The EU performs comparatively well in R&D spending, but there is a large gap in scale-up and deployment support.

Considering the different stages of the value chain of green technology deployment and where the EU provides financial support is instructive. If one considers where EU level funding is available, there is clearly a focus on the early stages in the innovation chain (research and development), with much less public financial support to the scale-up and deployment of clean solutions. However, at the later stages, there is much less funding for measures to scale up the supply of key clean technologies and support their market penetration – but instead a focus on demand side measures such as carbon pricing or standards.

The EU performs comparatively well in R&D spending. Overall, public R&D spending in the EU is relatively good in comparison to major competitors. Figure 9 shows total public R&D spending on energy technologies in the EU, US, Japan, and South Korea. Per unit of GDP, EU public RD&D spending is higher than in the US and South Korea and as high as in Japan. Two thirds of RD&D spending take place on MS level, however.

Figure 9 Total Public RD&D in Energy Technologies, nominal and as % of GDP

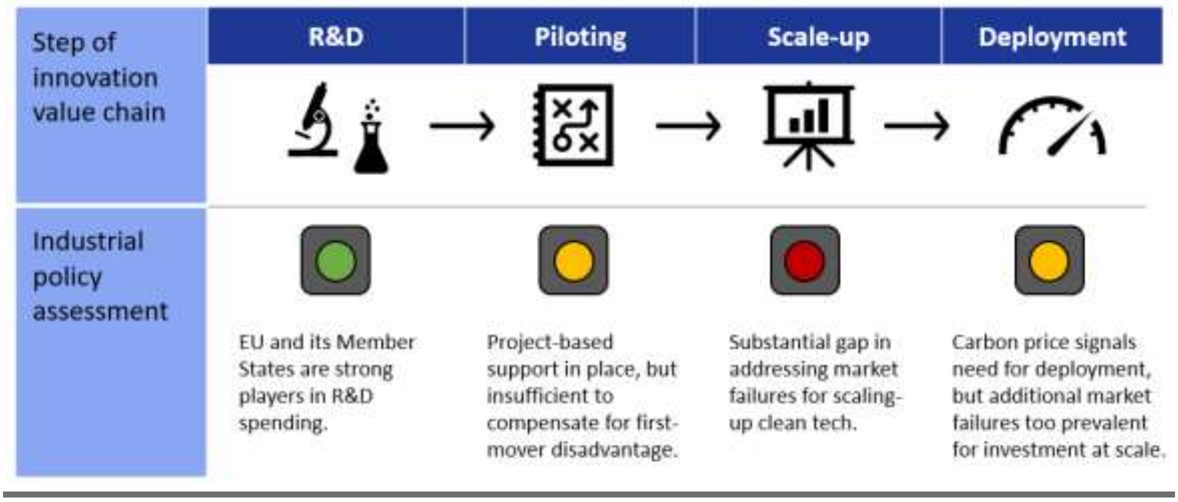


Note: Public RD&D spending in million USD (2023 prices) on the left-hand scale and in percent of GDP (thousand units; right-hand scale). European Union includes both EU-level (yellow) and MS-level R&D funding (green). *Source:* Authors illustration, based on IEA (2024b). Data for EU MS from JRC (2023).

However, there is a lack of (funding) instruments addressing first-mover-disadvantages and the capital market imperfections that hamper scale-up. As a result, the EU gives away its comparative advantage in early-stage clean tech innovation during subsequent steps of the innovation value chain (Draghi, 2024). The biggest innovation programme is Horizon Europe, which focuses on research and development. Only its Pillar III and the European Innovation Council focuses on demonstration, scale-up and commercialisation. In addition, the Innovation Fund provides support for the demonstration of low-carbon innovations. However, as noted, the volumes are insufficient and access, especially for scale-ups, is difficult. Taken together, this is a major impediment, specifically for the cleantech industry.

This lack of support for the scale-up and commercialisation of innovation is a major weakness of the EU's industrial policy mix, especially for cleantech (see also Humphreys, 2023). The phases in the innovation chain between the demonstration and deployment of new technologies is referred to as the "valley of death", because it is characterised by large risks and reduced incentives for private investment (Grubb et al., 2021). This policy gap becomes more apparent in comparison to the US: according to the EIB (2024), EU firms are relatively more capital constrained than US firms because of lower access to equity finance, especially for younger firms. In the overall market, the EU's per capita VC investment is only one eighth of that of the US, although this flows disproportionately to cleantech firms, which indicates the ability of the EU's policy framework to direct markets towards clean innovation. However, the EU has a lower share of cleantech innovators in the growth phases and a higher share in the early stages than the US. The gap in equity finance between the US and the EU is largest in the scale-up phase and particularly acute for smaller companies. In sum, the reported capital constraints indicate that the EU policy mix has gaps with regards to addressing capital-market-imperfections and first mover-disadvantages.

Figure 10 Assessment of EU policy incentives along the clean innovation value chain



Own visualisation

Next to lacking scale-up finance, the EU has little deployment support and instruments that incentivise investments in cleantech manufacturing. EU innovation support and other financial support tends to be project-based and focused on capital expenditures on the supply side. In contrast to the US' IRA, there is little support for deployment (Deloitte, 2023b), for example, through operational expenditure support (see Jansen et al., 2023).[6] In the context of cleantech and low-carbon industry competition, this puts EU industry and the policy framework at a comparative disadvantage to major competitors, such as China or the US, who directly support their industries with OPEX support. At Member State level, there is more deployment support available, especially investment support for households in the form of subsidies for EV's or heat pumps. In addition, some Member States provide OPEX support in the form of lower electricity tariffs for industry (such as the electricity price compensation) or dynamic subsidies such as Carbon Contracts for Difference, which were launched in Germany in 2024. However, at EU level, little OPEX and deployment support exists,[7] which risks fragmentation in the single market.

EU industrial policy relies heavily on MS funding, creating risks of fragmentation and efficiency losses.

Finally, there is a lack of EU coordinated industrial policy spending, but a heavy reliance on member state's spending. EU industrial policy relies on delegation to or permission for MS to spend on industrial policy. This creates strong inefficiencies and has various risks. Only Horizon Europe and the Innovation Fund are fully programmed at EU level. Most other instruments set general conditions, define eligible project, and provide guidelines but leave the programming and allocation, and sometimes the financing to member states. This is the case with Important Project of Common European Interest (IPCEI), for example, which Poitiers and Weil (2022) describe as "uncoordinated national approaches". Likewise, the RRF, the EU's single biggest climate spending facility is programmed individually by member states. This tendency towards member states deciding on industrial policy spending was reinforced through the EU's

[6] New measures such as resilience and sustainability requirements in auctions and public procurement are being phased-in with the Batteries Regulation or the NZIA. However, their effect on EU cleantech manufacturing is expected to be only modest.

[7] The EU considers introducing Carbon Contracts for Difference, a scheme launched in Germany in 2024, to provide variable OPEX subsidies to industry as part of their Innovation Fund in order to incentivise abatement actions currently not justified by existing carbon prices.

response to the Inflation Reduction Act (IRA): while the EU-coordinated response (NZIA, Strategic Technologies for Europe Platform (STEP)) had limited effect, the main response (also in terms of financial firing power) was to extend the transitional rules on state aid that applied during the pandemic and energy price crisis, allowing member states to support firms more. A more EU-focused approach towards industrial policy could in turn help resolve controversies around State Aid in the aftermath of these crises by enforcing State Aid rules at the national level more strictly again while extending support instruments at the EU level (Letta, 2024).

There are two major downsides to the EU's reliance on member state budgets and / or programming of industrial policy: a loss of efficiency and a risk of fragmentation. Programming and allocating financial instruments at EU level can potentially bring large efficiency gains for achieving climate and industrial policy objectives. These efficiency gains come because projects across the EU and potentially those more competitive are supported, and not just in those member states that can afford it. This may result in a better geographic siting of manufacturing plants or renewable energy resources. The European Hydrogen Bank (EHB) exemplifies this point very well: its function is to provides price subsidies to renewable hydrogen production in the EU. The subsidy is allocated through an EU-wide auction, those projects that require the lowest subsidy. In the first auction, this resulted in a very efficient allocation of subsidies, allowing a large volume of hydrogen to be produced with a relatively small funding volume. In addition, and as part of the EHB, member states can make use of the auction-as-a-service scheme, where member states provide additional funding that is then auctioned to those projects from the member state that provides the funding, who are the next best bidders in the EU wide auction. As McWilliams and Kneebone (2024) have documented, Germany was the only member state to use this scheme. An additional €350 million were thus provided to German bidders, resulting in the support of 0.09 GW of production. If the €350 million had been awarded through the EU-wide auction and projects from all MS were eligible, this would have supported 0.7 GW – eight times more. Consequently, an EU-level allocation of subsidies would have been much more efficient than a national allocation and more production supported.

The second issue with the high reliance of EU industrial policy on member state funding, is the risk of fragmentation – economically but also politically (E3G et al., 2024; Humphreys, 2023; Jansen et al., 2023). If most industrial policy is left to member states, this will be used primarily by those, who can afford it. Therefore, the EU's main response to the IRA – loosening of state aid rules – is not a sustainable solution.[8] The Temporary Crisis and Transition Framework primarily benefitted financially strong member states, as can be seen in Figure 11. This brings the risk of distorting competition in the single market, as some member states can subsidise domestic producers, whereas others cannot. This is especially relevant for the clean-tech sector or transition of industry, because some richer member states may try to attract investments into clean manufacturing, although these investments would have otherwise been made in other EU member states, due to natural competitiveness – a situation similar to the example of the EHB above.[9] In the extreme, there may be a situation, where some member states manage to finance the transition to a low-emission industry, whereas others cannot, resulting in a diverging transition in the EU. This economic fragmentation may ultimately result in political fragmentation, as poorer member states are left behind and revolt against the use of state aid. Such pushback is already visible.

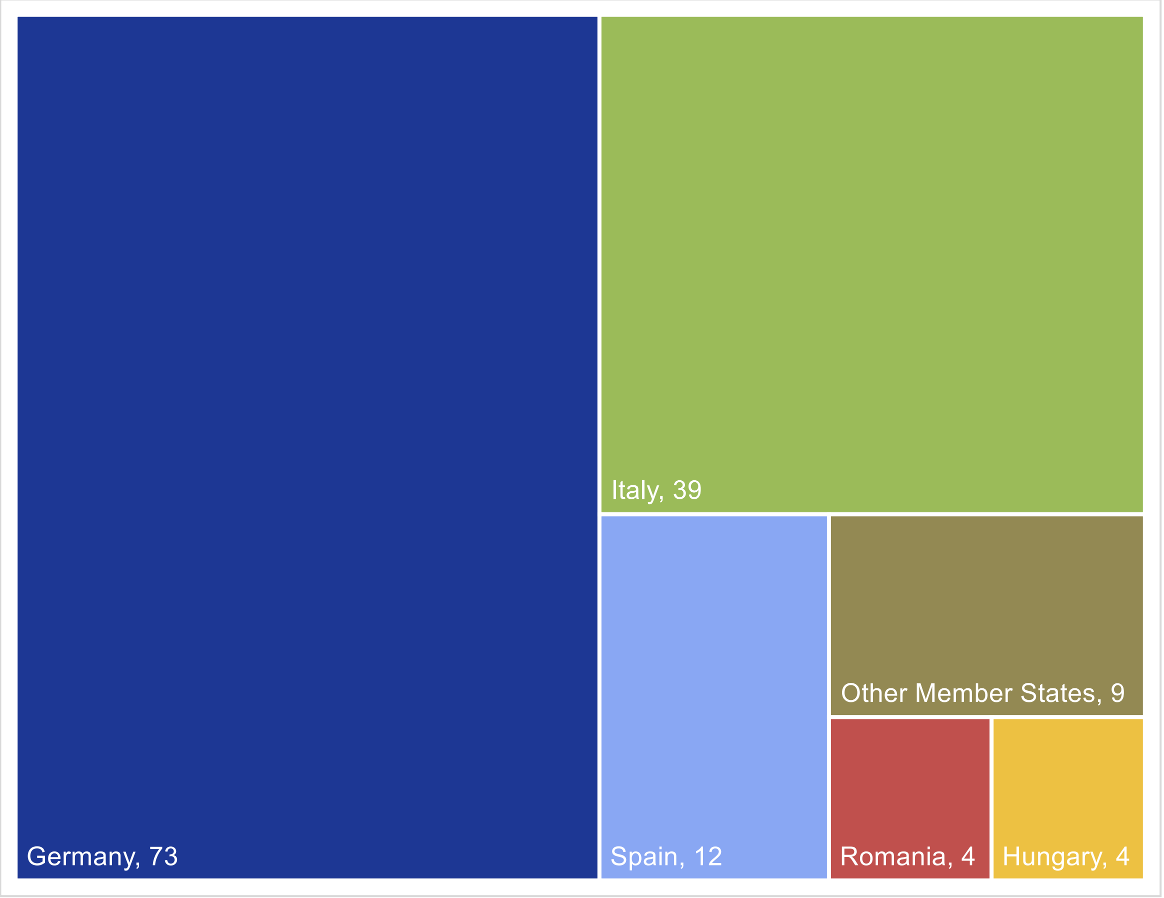
It should be noted that the EU generally has a very strict and transparent approach to state aid. There are clear conditions under which state aid may be approved. In some pre-specified cases, such as for renewable energy or industry decarbonisation, state aid must not be

[8] The TCTF also runs out at the end of 2025. At the latest then, the EU must find a sustainable solution.

[9] A good example is Germany's Carbon Contracts for Difference scheme, which was approved by the Commission under state aid rules in February 2024.

approved by the Commission under the General Block Exemption Regulation, with several conditions, such as maximum aid thresholds and that they must have an incentive effect. In other cases, the Commission decides on a case-by-case basis. Especially state aid that supports measures for reducing or removing GHG emissions can benefit from exemptions to state aid rules.[10] So generally, the EU has a strong environmental motivation towards exempting state aid rules. But this does not alleviate the general risks and disadvantages of delegating industrial policy spending to member states.

Figure 11 Total amount of state aid granted, March 2022 - June 2023 (billion €)



Source: DG COMP (2024)

While there are efficiency gains if industrial policy support instruments are designed and implemented at EU level, there is also a clear trade-off with political feasibility: particularly if industrial policy support is allocated in a competitive way, this means that Member States have limited control over the spatial distribution of support – in particular, achieving a "balanced" distribution of funding across Member States and regions is at odds with a distribution that prioritises efficiency, and where supported investments are centred in those European locations that offer the best conditions. This is likely to be met with resistance in those locations that expect to be on the losing end. Yet, since the goal is for European-based producers to remain or become competitive globally, in competition with locations that operate under more beneficial conditions, EU industrial policy is better advised to prioritise efficiency in the decision on where to locate investment support.

[10] According to Article 107(3)(c) of the Treaty on the Functioning of the European Union and the Guidelines on State aid for climate, environmental protection and energy ('CEEAG'). The TCTF also made explicit provisions for state aid to measures in support of industrial decarbonisation, renewable energy, and a net-zero economy (sections 2.5, 2.6, and 2.8).

Trade and the International Dimension of Industrial Policy

An important part of industrial policy is trade policy and engaging with partners. We have not included trade policy in our mapping. Still, without going into much detail, we want to mention two important and emergent aspects related to trade and the international dimension of industrial policy: the EU's use of trade defence policies and the need to embed industrial policy in an international strategy.

How the EU should deal and respond to the industrial policy of competitors, including with trade policy, is a central and politically sensitive issue in EU policy. The EU has consistently tried to pursue a World Trade Organization (WTO) compliant approach to its climate and industrial policy, one which has become increasingly challenging as competitors undermine the WTO regime. The EU has launched several probes into Chinese support to key industries, such as solar PV, wind, and electric vehicles. Following these investigations, the EU Commission has issued tariffs on EVs between 17.4% and 38.1%, in addition to existing 10% tariffs. This follows much more drastic tariffs by the US on EVs, semiconductors, solar PV, and other key clean technologies. In issuing trade measures, the EU must balance protecting its industries and meeting its climate goals. It must also balance constructive confrontation with China and remaining cooperative. Tariffs will increase costs for EU consumers, and consequently may slow down the deployment of EVs, solar power, or battery storage. It remains to be seen if they will help EU manufacturers catch up with Chinese competition. In any way, the EU must develop a coherent and effective trade policy for the new industrial policy competition. A central issue in doing so will be how the EU can contribute to maintaining a rules-based trade system, one that supports the benefits of trade for climate action, and hence, how the EU approaches the WTO in its policy design and outreach.

Closely related to this is the external dimension of an EU industrial policy. Experience with the CBAM has shown, that policies which may be WTO compatible and environmentally justified, may still illicit strong opposition from third countries. Feist et al. (2024) have documented that the EU's diplomatic approach to CBAM was reactive and uncoordinated. The likely (negative) impact on third countries and how it could be mitigated, especially for vulnerable countries, did not figure much in the instrument's design. A similar dynamic may unfold when the EU steps up its support to cleantech or industry decarbonisation, as most states will be unable to offer similar levels of subsidies. In consequence, the EU must learn from its mistakes with CBAM and develop a comprehensive external approach to its industrial policy and reflecting this both in diplomacy and instrument design.

3.3 Principles for selection and design of IP instruments

Based on the considerations outlined above, we argue that an EU industrial policy should adhere to the following principles to become more aligned with the EU's climate goals:

1. **Address specific market failures with targeted instruments.** This is the prima facie motivation for market interventions. At the same time, market failures are difficult to detect a priori (Juhász et al., 2023). The EU must therefore adopt an experimental and adaptive approach that takes risk and corrects policy flexibly.

2. **Prioritise industrial policy where it adds value.** Technologies where either the EU innovation ecosystem already results in a competitive edge, or where there is a strategic case for domestic manufacturing capacities should be the starting point for prioritisation (Draghi, 2024). The NZIA ended up too broad, resulting in little prioritisation for key sectors and technologies, spreading out the available resources too thinly. Given that EU resources are limited (more so than those of its competitors), it is all the more

necessary to prioritise sectors and technologies, focusing on those where the EU can maintain or gain technological leadership and those that are structurally or strategically important for decarbonisation (see Jansen et al., 2023). Of particular interest are technologies that are crucial both to build up new cleantech industries and decarbonise incumbent industry, such as electrolysers, CCUS, or large heat pumps. For both the transformation of incumbent industry and the ramp-up of key clean technologies, we therefore advocate for vertical industrial policy measures rather than horizontal approaches. This implies political decisions about which sectors and value chain segments to keep in the EU, even if at a higher cost, and which ones to let go, as well as resisting the desire to keep all options under the guise of technological neutrality. In addition to current or future competitiveness in key clean technologies, prioritisation can also reflect aspects such as import dependence and resilience, provided that targets and their hierarchy are clearly defined (see chapter 4).

3. **Develop policies that address value chains and market integration.** industrial policy needs to consider the entire value chain for key clean technologies to identify those parts of the value chain where EU producers are best placed to secure a lead. Industrial policies must also support the emergence of markets: they are not only about building up know-how and production capacities, but also needs to address the demand for climate-friendly products. Demand can be stimulated through fiscal policy or through other economic incentives, including carbon pricing, but also through efforts to roll out lead markets for green technologies, including through the strategic use of public procurement as a source of demand.
4. **Design and implement support measures at EU level.** Allocating subsidies across the EU single market will be more efficient than a fragmented approach at the level of the Member States. It will also make the competitive allocation of support measures more likely, avoid distortions in the single market, and prevent political fragmentation. In addition, a more EU-focused approach towards industrial policy could help resolve controversies around State Aid by enforcing State Aid rules at the national level more strictly again while extending support instruments at the EU level (Letta, 2024).
5. **Allocate support through competitive mechanisms and equip policies with clear conditionalities and sunset clauses.** Such approaches are more conducive to effective risk-sharing between state and private actors, improve efficiency, and reduce the risk of subsidy-dependence. Given political and budgetary constraints, financial support to firms must be allocated in an efficient way – to this end, auctions and other competitive policy designs should be used. Moreover, support should come with clear conditionalities. Finally, there must be a clear exit strategy for support through sunset clauses and empowered public managers. The design of the European Hydrogen Bank serves as a good example.
6. **Embed EU industrial policy in a strategy for outreach and diplomacy, bilateral cooperation, and trade.** Effects on third countries must be considered in instrument design. The EU is trying to respect WTO rules and regulations, as can be seen with CBAM or the countervailing tariffs on EVs, but it has been too reactive and uncoordinated in its communication and cooperation with third-countries to pre-empt opposition (Feist et al., 2024). Supporting third countries that invest in climate-friendly solutions can help to sustain coalitions of like-minded countries with shared interests. But it can also serve to diversify suppliers and reduce geopolitical risks, including through foreign direct investment and transition partnerships (see chapter 4 below).

Figure 12 Principles for the selection and design of industrial policy instruments

6 Principles for Industrial Policy Instruments
1. Address specific market failures with targeted instruments
2. Prioritise industrial policy where it adds value
3. Develop policies that address value chains and market integration
4. Design and implement support measures at EU level
5. Allocate support through competitive mechanisms and equip policies with clear conditionalities and sunset clauses
6. Embed EU industrial policy in a strategy for outreach and diplomacy, bilateral cooperation, and trade

Own visualisation

4 Climate, competitiveness, security: navigating the industrial policy trilemma

The previous chapter sketched how industrial policy could support the transformation of the EU economy to climate neutrality. **But industrial policy may also be invoked to pursue other priorities such as strategic autonomy, (economic) resilience towards trade-induced shocks, (national) security, job creation, or simply competitiveness.** On the face of it, this does not fit into the market failure framework described in the previous chapter. But addressing such priorities with industrial policy can be justified with similar arguments. Yet in doing so, there will be trade-offs between different policy objectives. So, what does this mean for the EU's industrial policy mix?

Security, autonomy, resilience, social stability and climate change mitigation – **these objectives have characteristics of a public good**, in the sense that their full social marginal costs and benefits are not internalised in market prices and actions. Hence, their (non-market) provision may be socially beneficial and justify market intervention. Rodrik (2022), for example, argues that industrial policies should, in addition to technological and environmental externalities, target "good-jobs externalities", the positive social, political, and economic benefits that result from high quality (and full) employment. Similarly, increased national security that results from reduced dependencies on single suppliers can be conceived of as a positive externality (Juhász et al., 2023, p. 5).

But, as Tagliapietra and Veugelers (2023), among others, point out, there are trade-offs in pursuing different, competing objectives with industrial policy, even if they individually represent public goods. They refer to the "industrial policy trilemma" as the trade-off between (i) decarbonisation, (ii) competitiveness or growth, and (iii) strategic autonomy or resilience. For example, decreasing trade dependencies on China in renewable energy technologies by protecting and supporting domestic production may bring the benefits of increased security and autonomy, and may increase (at least temporarily) economic activity in the protected sector. But it would also mean increasing the cost of decarbonisation, as cheaper imports are substituted by domestic production. Similar trade-offs exist outside the EU, although the exact form is contingent on multiple factors, among them the structure of the EU economy, its trade relations, the state of the energy transition and many others.

This trade-off is acutely encapsulated in the question whether – and how – the EU should support domestic cleantech manufacturing? Under the impression of disruptions to value chains during the Pandemic, China's dominance in clean value chains, the US' pivot to green industrial policy, and the realisation of dependencies ensuing Russia's aggression against Ukraine, the EU responded with bold targets to diversify its supply and reshore production. This cumulated in the EU's Critical Raw Materials Act and bold (yet non-binding) self-sufficiency targets for strategic "net-zero technologies" in the Net-Zero Industry Act. Essentially, the targets and rhetoric call for strong import-substitution in renewable energy technologies, although the EU has not yet translated these targets into policy that would actually support and protect domestic production.

The quest to protect and boost domestic production is motivated by **security concerns** on the one hand and **economic concerns** on the other. While both are legitimate, there is a need for nuance and recognising trade-offs.

- Regarding security concerns, **not all imports are a risk to security of supply**. When proposing its self-sufficiency targets in the NZIA, the Commission has failed to motivate them sufficiently (Tagliapietra et al., 2023). What are the exact risks in relying on imports? How large is the risk that China will no longer supply technologies to the EU market? As Mazzocco (2023) and others have pointed out, there are some security risks but mostly concerning critical infrastructure and foreign ownership, and less so in imports. And even if the strong dependency on Chinese imports is a national security threat, this does not mean that import substitution is the right answer, as we detail below.
- Regarding economic concerns, the desire to maintain or gain technological leadership in key technologies must be balanced against the benefits of international division of labour. The EU itself is the best proof of the **substantial benefits that accrue from trade and the international division of labour.** Foregoing some of these gains of trade can have high costs: substituting imports will increase the cost of the energy transition.[11] Tariffs on solar panels, EVs, or electrolysers will make these more expensive for EU consumers and delays the moment where they reach cost parity with incumbent, fossil-based technologies, and will thus slow their deployment. Production

[11] As Agora Energiewende and Agora Industry (2023) make clear, scaling-up cleantech manufacturing in the EU would require closing the OPEX gap, because European production faces higher labour and energy costs.

subsidies for EU manufacturers or local-content requirements will likewise increase the cost of the transition (Agora Energiewende and Agora Industry, 2023). Moreover, restricting imports or foreign investment into the EU may depress innovation. Many Chinese firms are now leaders in technologies such as batteries. Protecting the EU market from this competition may slow-down innovation and harm the EU's innovative capacity in the long run (Mazzocco, 2023).

Industrial policy support to EU producers should therefore be targeted. Commenting on the sluggish effectiveness of the US' solar tariffs, Semieniuk (2022) argues that high-wage technology leaders should "focus on innovation at the tech frontier", so as to forego costly support policies that have little benefit for overall competitiveness. For the EU, this means that it would be ill-advised to try to reshore production in what are highly commoditised mid-tech goods, such as solar panels. Instead, Jansen et al. (2023, p. 2) argue that the EU should prioritise those sectors and technologies, where support is conducive to reaching EU climate targets and that have "broader implications for European growth and investment and in which the EU can develop a competitive edge". They argue that this is the case for hydrogen, which is important for the decarbonisation of many downstream sectors, or batteries, which are essential for EVs and decarbonising the EU's automotive industry, a strategically important economic sector.

In summary, to balance the trilemma between climate, competitiveness, and security the EU approach should follow **guiding principles**:

1. **Commit clearly to the transformation challenge.**

Restricting imports or foreign investment for key clean technologies may have the unwanted effect of reducing the incentive and pressure for European manufacturers to innovate, particularly in sectors where non-EU firms are technologically more advanced. This perception would ultimately harm the EU's long-term competitiveness and innovative capacity and must thus be avoided. Instead, the EU should focus on attracting investments (incl. foreign direct investment), by enhancing the investment framework landscape, e.g. through and using targeted subsidies and trade measures strategically.

2. **Focus on innovation through R&D, demonstration, and piloting.**

While the EU is still an innovation leader for key clean technologies, it gives away its early-stage comparative advantage through weaknesses in subsequent steps of the innovation value chain (Draghi, 2024). The EU should focus their industrial policy efforts on those technologies where it plays a role at the technological frontier. This will mean different strategies for different sectors and technologies. In research and development, the EU remains to play a dominant role in cleantech globally (Joint Research Centre, 2023). A focus on innovation should also guide support for EU manufacturing. In its trade defence measures, the EU should pursue a targeted approach that levels the playing field but maintains (international) competition (Leichthammer & Redeker, 2024).

When it comes to supporting EU production, the EU should focus on those sectors at the technological frontier and where domestic production is strategic for climate action. The EU should try to couple support to innovation, not just local content. The Commission's current approach to introduce high circularity, sustainability, and labour standards for key technologies, such as batteries, is a good example for a policy that will likely support EU production, while encouraging innovation. However, for some technologies, a solid EU manufacturing base is desirable for security, jobs, and for maintaining the whole innovation ecosystem in the EU.[12]

3. **Derisk smartly, not bluntly.**

Derisking the EU's supply dependencies is important as an insurance for the energy transition and to avoid supply bottlenecks. But again, this does not mean bluntly protecting EU production, but derisking smartly, focusing on those (intermediate) products and value chains where the EU depends on imports from a single supplier (Pisani-Ferry et al., 2024), but also those where the single supplier may have an interest to exploit the EU's import dependence.[13] Smart derisking can work, first, by diversifying supply through countervailing duties, bilateral partnerships, encouraging EU firms to diversify their imports. Second, through strategic stockpiling of key inputs for key clean technologies, such as semiconductors. Third, by encouraging circularity and doubling-down on support for the recycling of technologies such as solar panels or batteries (McWilliams, Simone, et al., 2024). Finally, by encouraging foreign direct investment and joint ventures with foreign companies in the EU. While national security risks must be mitigated in Foreign Direct Investment (FDI), especially in critical infrastructure, this last strategy can increase mutual interdependence and thus reduce political risks as the costs of decoupling increase for both sides.

4. **Encourage investments in the EU to create jobs and support technological diffusion.**

Finally, creating jobs in cleantech value chains is a separate goal – but perhaps the key lever to resolve the political economy of the climate transition. However, bluntly protecting EU production from international competition will be costly and is unlikely to create lasting, high-quality employment, if the jobs created are dependent on sustained subsidies or protection from foreign competition. For example, protecting EU solar PV production through import tariffs will slow deployment – yet the large majority of jobs in the PV value chain in the EU is not in manufacturing, but in deployment and maintenance. A narrow focus on manufacturing jobs can thus backfire.

To create jobs in clean value chains in the EU, the EU must encourage investments, including foreign direct investment (Mazzocco, 2023). Instead of fully banning foreign producers, the EU should develop a strategy for attracting foreign direct investment and joint ventures in the EU, by improving the investment framework, targeted subsidies, and an intelligent use of trade defence measures. This is particularly important in the automotive value chain, which is a strategic industry for EU employment. Attracting FDI will not only create jobs, but also diffuse technology. As China is leading innovation in some key technologies, such diffusion will benefit the EU's innovation capacity and help it maintain an important role. Nonetheless, in attracting FDI, the EU must remain cautious and balance national security considerations.

[12] A crucial question is to what extent having an EU manufacturing base in clean technologies is important for remaining a key player in research and development and for maintaining innovation capacity.

[13] Whether or not import dependency represents an excessive risk depends on different factors – not all import dependency is equally likely to be weaponised against the EU. For instance, China has little interest to stop the sale of PV modules to the EU, neither for the global energy transition, nor in terms of utilising the extensive manufacturing capacities in China. Yet it may be very much in Chinas interest to use its near dominance for permanent magnets to prevent EU manufacturers from catching up with wind turbines or EVs (Prognos et al., 2023).

5 Conclusions and recommendations

EU industry is at a critical moment. While incumbent industries struggle to transform and face risks to their business model in a future defossilised, climate-neutral economy, EU producers of key clean technologies fight to defend their position in the race for climate-neutral competitiveness. The next legislative cycle is crucial, and the Commission must manage to balance competing policy priorities, while developing a coherent and ambitious EU industrial policy consistent with the transformation to climate neutrality. Crucially, the EU must stay course with its existing climate policy framework to provide certainty and direction for firms and investors. At the same time, the EU must develop its climate-industrial toolkit and deploy industrial policy at the EU level. Otherwise, the EU risks further falling behind internationally, fragmenting the single market, and encountering (further) political backlash against its climate ambitions.

We have developed principles and guidelines for an industrial policy focused on public goods and market failures, while mitigating existing trade-offs.

- **Industrial policy needs to be based on clear principles, pursue clear objectives and address specific market failures**. Technological leadership and competitiveness, reduced reliance on exports, domestic job creation and lower cost of key clean technologies are all worthwhile goals – but an industrial policy that seeks to achieve all of them all of the time is bound to overstretch itself.
- **Industrial policy needs to set priorities.** Funds are limited, as well as the administrative capacity to ensure that funds are used efficiently. Unclear or lacking priorities create a risk of spreading limited funds too thinly and therefore failing to have any impact. This implies political decisions about which sectors and value chain segments are kept in the EU, even if at a higher cost, and which ones to let go.
- **Industrial policy involves picking winners** (and thus also losers) among technologies**.** While industrial policy must be open to technological advancements and disappointments, and may in some cases support competing solutions, it cannot be technology-neutral.
- **Industrial policy can contribute to greater security and resilience.** As a matter of focus and priorities, however, it needs to be based on a solid assessment where domestic manufacturing has a chance of becoming (and staying) competitive, or where domestic production is deemed to be of strategic significance. “Autarky first” is not a good strategy since it will drive up costs and alienate partners, and not every case of imports is a security risk.
- **Industrial policy needs to think value chains, not products.** The distinction between technologies or sectors is often too coarse – the relevant question is rather for which parts of value chains the EU can be a competitive location, or which parts of value chains the EU needs to retain control over. Thinking along value chains is even more relevant as many of them will be re-organised during the transformation – to achieve greater circularity and to replace fossil resources as fuels and feedstocks.
- **EU industrial policy needs to think both domains together: fostering clean technologies and transforming basic industries.** The EU is endowed with a strong industrial base, a rich history of industrial innovation, and the physical and research infrastructure to support it. It also has strengths across many key clean technologies that will shape the defossilised, climate-neutral economy. EU industrial policy should thus combine efforts in both domains and think them together – including “dual” technologies such as carbon capture, large heat pumps or hydrogen-based fuels and feedstocks that fall into both categories.

In doing so, the EU can build on a number of related initiatives, programmes, funds and institutions. But for an effective governance of industrial policy at EU level, we see three core challenges that the Clean Industrial Deal will need to resolve:

How to organise the process of deciding which technologies to support?

Which institution decides, based on what information, which technologies and investment opportunities should receive support, who monitors performance and evaluates the spending based on which criteria? Identifying the most promising *sectors* is perhaps the least controversial aspect, where a sector-by-sector approach as proposed in the Draghi report is sensible and should be feasible in collaboration between elected politicians and specialised agencies. Trickier is the identification of *categories of technologies* eligible for support: the NZIA and the sustainable finance taxonomy exemplify the risk that political interference in this process can lead to lists of technologies that are too long, lack focus and prioritisation, or reflect political priors rather than technological or economic opportunities. It may thus be advisable to put specialised, independent agencies in the driving seat for this part of the process. For the selection of *specific projects and applications*, there is knowledge and institutional capacity that the EU can build on: EU institutions have gained experience in (i) reducing information asymmetry to firms through project-based support and competitive bidding processes such as under the Innovation Fund, as well as in (ii) creating systematic platforms for exchange with companies and civil society, including public private partnerships such as the Clean Hydrogen Partnership. Overall, given the international competition for clean technologies, it appears more sensible to get going and adjust decisions later, rather than seeking to find the optimal solution, and rather ensure that any support instrument comes with exit strategies and strict conditionalities.

How to address the spatial dimension of industrial policy and distributional effects?

Concentrating industrial policy support at EU level offers potential for efficiency gains but requires that Member States relinquish control over which share of the funding ends up supporting their national industries. “Efficiency gains” also entail that the funding benefits those locations and regions with the most favourable conditions – wherever these may be located across the entire EU. Access to reliable and affordable energy is a key determinant for location decisions of energy-intensive industries – yet going forward, this will not be defined by the endowment with fossil resources, but rather the abundance of renewable electricity and/or green hydrogen. A central dilemma is therefore to navigate the trade-off between a spatial distribution that maximises efficiency, and one that is based on solidarity. While there is no easy way to define the sweet spot, it is clear that an efficient and just transition will not happen if Member States with deep pockets subsidise their domestic industry along the road to transformation, while poor regions are left behind. Only a coordinated, European effort that combines support instruments with tough rules on State Aid can ensure a good balance of efficiency and solidarity.

How to ensure sufficient and reliable funding in times of competing budgets?

Private investors need to be convinced that sufficient public co-funding will be available, with a credible commitment to provide such funding as long as needed, and at the scale needed. In this regard, the IRA sets the benchmark as a policy that has created this expectation – whereas the EU’s initial answer, the Strategic Technologies for Europe Platform, illustrates the risk of combining high ambitions with inadequate funding. It is the subject of much heated debate whether sufficient predictable funding requires new own resources for the EU Commission, or even common borrowing. To prevent this aspect from derailing the broader discussion on EU-level industrial policy, it is important to not put the horse before the cart: the source of funding is secondary – the main issue, rather, is that sufficient funding is available in a reliable and predictable way.

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