

Competitiveness and Opportunities for European Clean Tech

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1 Introduction

Though Europeans have pioneered many green technologies, Europe is currently losing some competitiveness in the production of those technologies. This slowdown affects different countries and regions differently. Boosting competitiveness at the aggregate level should therefore involve approaches that take into account diverse regional industrial capabilities.

In this paper, we evaluate Europe's positioning in green technologies and identify opportunities for Europe to translate its industrial capabilities into leadership of green value chains. We use two datasets – the Greenplexity dataset from the Harvard Growth Lab, and the European Clean Tech Tracker from Bruegel (Growth Lab, 2025; Bruegel Dataset, 2025) – to explore trends at national and regional levels.

We identify the sectors and regions in which Europe can strengthen its position, build competitiveness in new industries and generate economic growth through the energy transition. We conclude with policy priorities for guiding clean-technology investments, arguing that policymakers should use the feasibility and attractiveness of industrial clusters to target investment support at regional level.

2 Europe is modestly losing ground in clean-technology exports

2.1 What do we measure?

We measure European countries' exports of products in green value chains and use this to assess countries' competitiveness in different industries. By 'value chains' we refer to the main raw materials, inputs and components for each class of energy technologies. We use the word 'green' throughout to refer to ten specific value chains relevant for energy systems with low to zero greenhouse gas emissions: batteries, critical minerals, electric grid, electric vehicles, heat pumps, hydroelectric power, fuel cells, nuclear power, solar power and wind power.

The value chain for wind turbines, for example, includes steel and fiberglass, among other materials, and components such as gearboxes, magnets and nacelles. We also refer to 'industries' as specific product markets within a value chain, such as fiberglass or magnets. By 'industrial clusters', we mean clusters of very similar industries that are smaller than a value chain, but larger than a specific product category – for example, bulk chemicals or catalytical materials are two separate clusters that involve multiple industries and contribute to multiple value chains. Industrial products are therefore organised into industrial clusters, which are nested in value chains (Li *et al*, 2026).

For our purposes, a country is 'competitive' in an industry if trade data shows that its products earn a higher-than-expected market share: if, therefore, that industry's share

of the country's exports is greater than that industry's share of world exports (this is known as the Balassa index or 'revealed comparative advantage' (RCA); Balassa, 1965)¹. This suggests the country is outcompeting other countries in production in that industry, offering higher productivity, lower prices and better quality than its competitors.

We also assess which countries have the potential to become competitive in an industry, based on two sets of measures:

1. Measures of economic complexity help assess which industries a country can compete in, based on whether that country hosts related industries². If a country can competitively host related industries, that suggests it has the capabilities to compete in the industry in question.
2. We assess which countries are attracting investment in manufacturing plants and equipment in clean technology value chains using Bruegel's European Clean Tech Tracker (Bruegel Dataset, 2025). Investors consider countries that receive investment to be potentially more competitive in production than other countries, and investment in manufacturing plant and equipment suggests future increases in production, relative to countries that do not receive this investment.

2.2 The European Union's position relative to global peers

Our analysis shows that the EU has a strong industrial base in advanced manufacturing generally and has diverse capabilities across green value chains. However, the EU's positioning within these value chains appears to be worsening. The EU is losing some of these industries and is, on average, starting to occupy lower complexity positions within these value chains.

We measure the EU's position in green value chains using the Greenplexity index, which ranks countries based on the breadth and complexity of their industries: countries that are competitive in more and more-complex industries in green value chains rank higher.

Economic research shows that diversifying into more and more-complex industries drives economic growth. Conversely, losing competitiveness in industries (and especially complex industries) hurts countries' growth prospects (Balland *et al*, 2019; Hausmann *et al*, 2014). A decline in Greenplexity score thus suggests that the EU is losing competitiveness in the industries that constitute value chains for green technologies, implying that it is less well-positioned to generate economic growth from these industries.

1 For example, in an imaginary global system electrical transformer exports account for 10 percent of global exports. For a country that itself also has electrical transformer exports equal to 10 percent of total exports, its RCA in transformers would be 1. If another country has transformers as 20 percent of its exports, RCA would be 2.

2 'Economic complexity' in this paper refers to the branch of economic geography that uses network sciences approaches to study relatedness, diversification, and economic growth, rather than the broader umbrella term of 'complexity economics', which refers to interdisciplinary approaches to the study of economics.

Box 1: What is the Greenplexity Index?

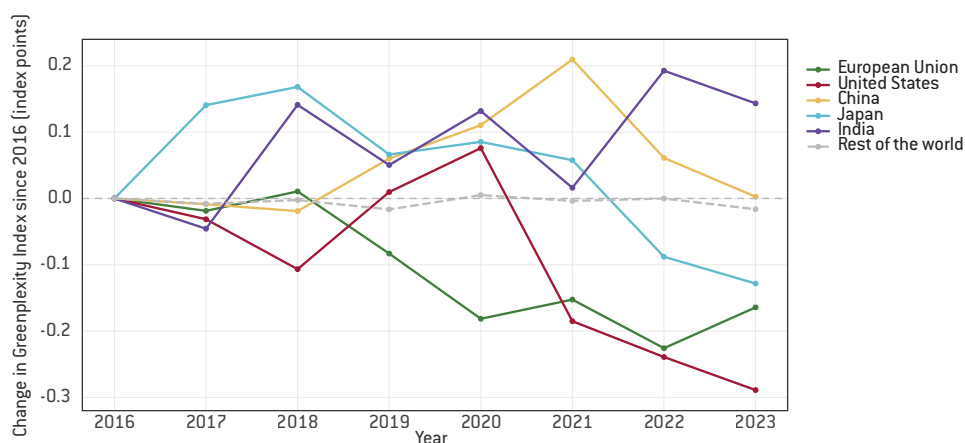
The Greenplexity Index, first published by Harvard's Growth Lab in 2025 (Growth Lab, 2025), captures the extent to which countries are competitive in the industries that make up green technology value chains. Scores combine two things, for the industries that make up clean value chains taken together:

1. The number of industries in green value chains that a country is competitive in (in the sense above, of revealed comparative advantage).
2. The average complexity of the green value chain industries in which a country is competitive.

Countries score higher on the Greenplexity Index if they are competitive in more green value chain industries, and those industries are of higher average complexity. The index covers ten green value chains: batteries, critical minerals, electric grid, electric vehicles, heat pumps, hydroelectric power, fuel cells, nuclear power, solar power and wind power.

The EU's positioning in green value chains is deteriorating modestly compared with its geopolitical peers (Figure 1). Its position was stable, according to the Greenplexity Index, until 2018, but since 2018 has modestly deteriorated. The positions of the United States and Japan are also deteriorating while India's position has improved over time, and China has sustained its ranking.

Figure 1: Changes in the Greenplexity Index since 2016



Source: Bruegel and Growth Lab (2025). Note: European Union = EU28 (includes the UK). European Union and rest of the world are each year's median across constituent countries.

3 National positioning across green value chains

3.1 Absolute positions in the Greenplexity index

Figure 1 emphasises relative regional changes in the Greenplexity Index over time, by rebasing the index to start at 0 for each region. But the absolute positions of countries and regions also differ when not rebased; China and the US have higher absolute Greenplexity rankings than the EU. Figure 2 shows variation in absolute country rankings, with several European countries ranked highly.

Figure 2: Absolute Greenplexity Index rankings for selected countries

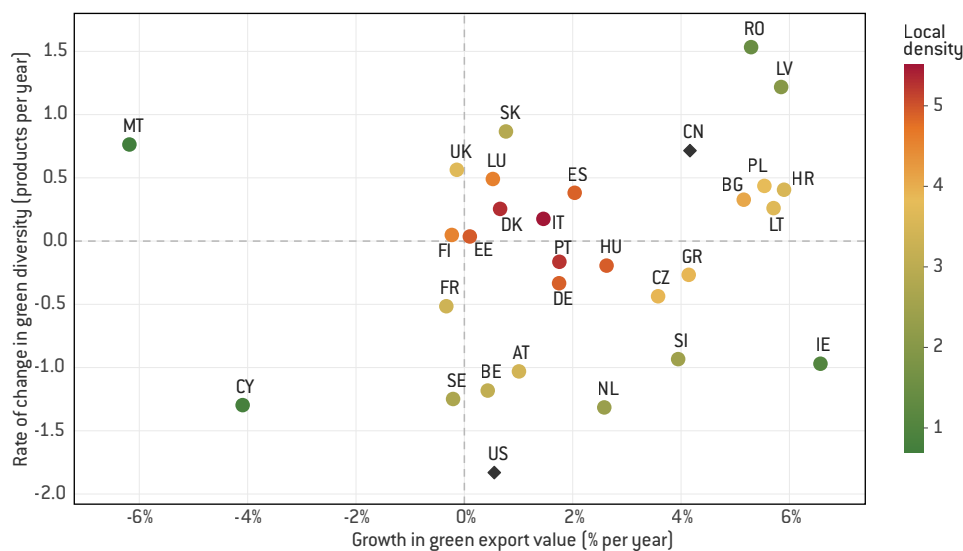
Country	Greenplexity Index	Rank	Change since 2016
Japan	3.430	1	
Germany	3.318	2	
Czechia	2.740	3	
France	2.633	4	
China	2.625	5	
Italy	2.491	6	
Austria	2.477	7	
United Kingdom	2.442	8	
United States of America	2.401	9	
Hungary	2.386	10	
Romania	2.333	11	
Slovenia	2.173	13	
Poland	2.104	14	
Sweden	2.098	15	
Denmark	2.044	16	
Slovakia	1.828	20	
Finland	1.749	21	
Belgium	1.688	22	
Netherlands	1.551	24	
Spain	1.440	26	
Estonia	1.373	28	
Croatia	1.328	29	
Lithuania	1.313	30	
India	1.121	34	
Latvia	1.071	35	
Bulgaria	1.037	36	
Portugal	1.032	37	
Ireland	0.320	49	
Greece	0.182	53	
Cyprus	-0.133	61	

Source: Bruegel and Growth Lab (2025). Note: bold rows are non-EU comparators as designated in the supplied data. Sparklines: 2016–2023; dashed line = zero; shared scale.

Although the EU overall is modestly losing competitiveness in green value chains, there is variation across European countries. While Czechia and Hungary have lost some competitiveness, they remain very well positioned. Other countries are reasonably well ranked and are improving their positions, such as Poland and Romania.

The Greenplexity Index is influenced by how many green industries each region is competitive in, and how competitive regions are in each industry. Figure 3 separates these two components, showing on the y-axis 'green diversity', ie how many green industries a country is competitive in, and on the x-axis, 'green exports', or how much green value a country exports. Some European countries (mostly in eastern Europe) are becoming more competitive in a wider range of products, while other countries (mostly in western Europe) are losing competitiveness in many products in green value chains (positioned lower on the y-axis on Figure 3).

Figure 3: Green value chain competitiveness evolution, 2014 to 2023



Source: Bruegel and Growth Lab (2025).

Industries in green value chains are, for the most part, growing rapidly. This means that many countries are increasing their absolute exports in these industries, even while they are becoming more specialised in smaller subsets of industries. Countries such as Germany, the Netherlands and Czechia have increased the absolute values of exports significantly, while losing competitiveness in several of these industries.

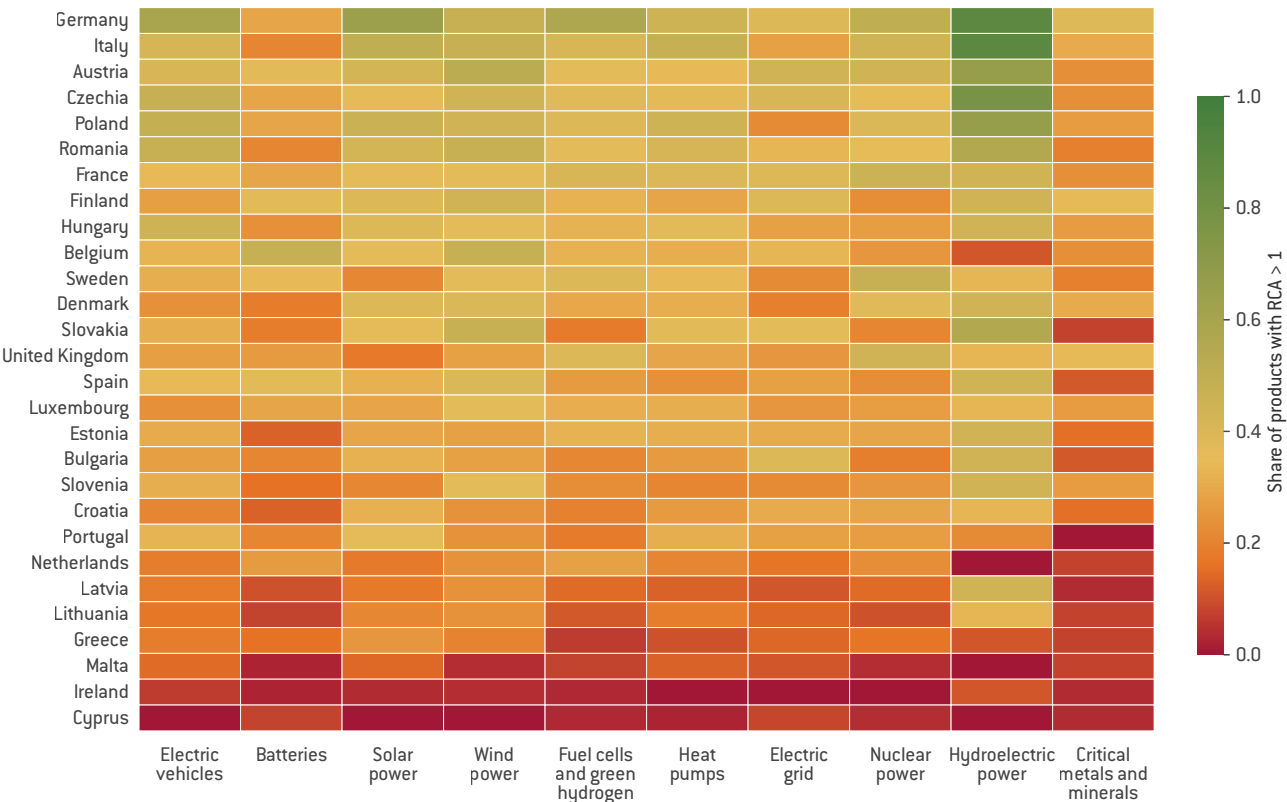
Deepening specialisation is undesirable for the countries that face this dynamic, even if it is accompanied by absolute growth from these industries in aggregate. Economic research suggests that countries grow primarily by developing new capabilities and diversifying into new industries, rather than by increasing exports in their existing industries (Hidalgo and Hausmann, 2009; Hausmann *et al*, 2014). Relying on narrower sets of industries within green value chains to deliver growth from the sector represents deteriorating strategic positioning. Europe needs to increase its absolute exports while diversifying into more-complex, large and fast-growing industries.

Overall, Europe remains a highly capable, complex, clean-technology economy, with extensive productive capabilities in green value chains. This provides a good foundation for future European growth: more-complex economies have broader and more sophisticated productive capabilities, which they can apply to diversify and compete in new areas of economic activity. But Europe's position in these value chains is modestly deteriorating, as it is losing competitiveness in some of these industries.

3.2 Specific national strengths across green value chains

European country strengths are also different across different green value chains (Figure 4). Belgium, for example, has a good industrial base in batteries and wind power, while Portugal is relatively more present in electric vehicles and solar power than in other chains. By contrast, other countries have industrial strengths across wide ranges of value chains. This is particularly true of larger manufacturing powerhouses including Germany, Poland and Czechia. While most European countries have some presence in green value chains, a few European countries (particularly the islands of Malta, Ireland and Cyprus) have very limited presence in these industries. While these value chains include wide varieties of different products, in general, industries in green value chains are growing strongly, are more complex than the average industry in global trade, and are closely interconnected (Li *et al*, 2026).

Figure 4: National European strengths across green value chains



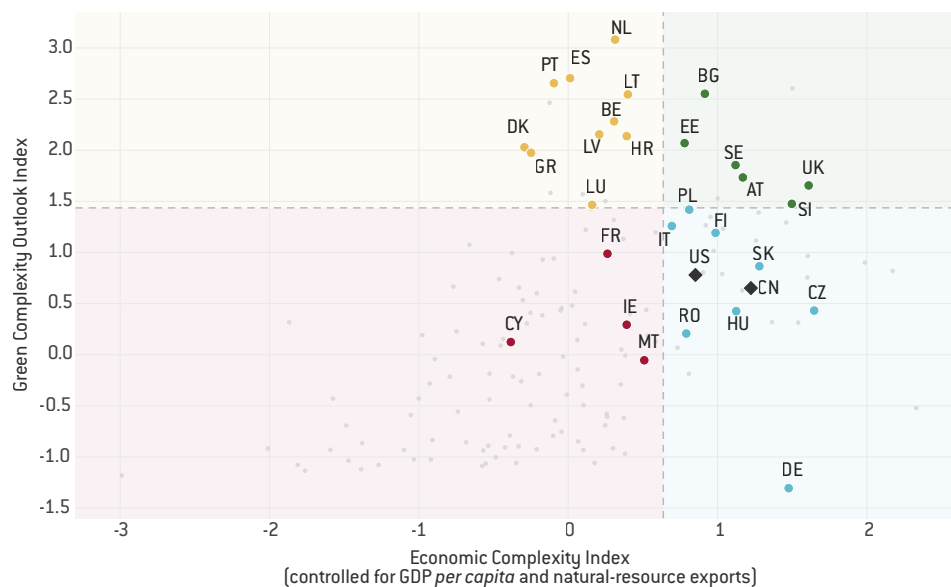
Source: Bruegel and Growth Lab (2025). Note: each green value chain is composed of a set of products. The share value indicates the proportion of products in that value chain for which a country has an RCA >1. For example, Germany's dark green 0.85 share score for hydroelectric indicates that Germany has an RCA greater than 1 for 85 percent of the products which make up the hydroelectric value chain.

3.3 Identifying national opportunities across green value chains

European countries can be thought of as part of different 'opportunity groups', based on their portfolios of green industries and their current economic complexity. Figure 6 plots the positions of European countries in this 'strategy space', by charting countries' economic complexity against their green complexity outlook index (COI) scores (Hausmann et al. 2014).

The green COI measures how well positioned countries are to diversify into new industries in green value chains: a high green COI suggests that there are many nearby complex green products that rely on similar capabilities or know-how to those the country already has (Mealy and Teytelboym 2022). Countries that score high on both axes (Figure 5) are generally complex economies (x axis), with a wide range of good opportunities in green value chains (y axis).

Figure 5: European countries by green 'opportunity groups' (2023)



Source: Bruegel and Growth Lab (2025).

The four quadrants of Figure 5 suggest four broad groupings:

- *Complex with many opportunities* (top right): these countries, such as Sweden and Bulgaria, are both complex and well positioned to diversify into new industries in green value chains. These countries have much to gain from the energy transition, through exploiting nearby industrial opportunities.
- *Less complex with many opportunities* (top left): these countries, including Spain and Denmark, are less complex, but still have many opportunities in green value chains. Policy in these countries should focus on developing the most complex industries related to what the country already produces, using these green industries to diversify into complex new sectors.

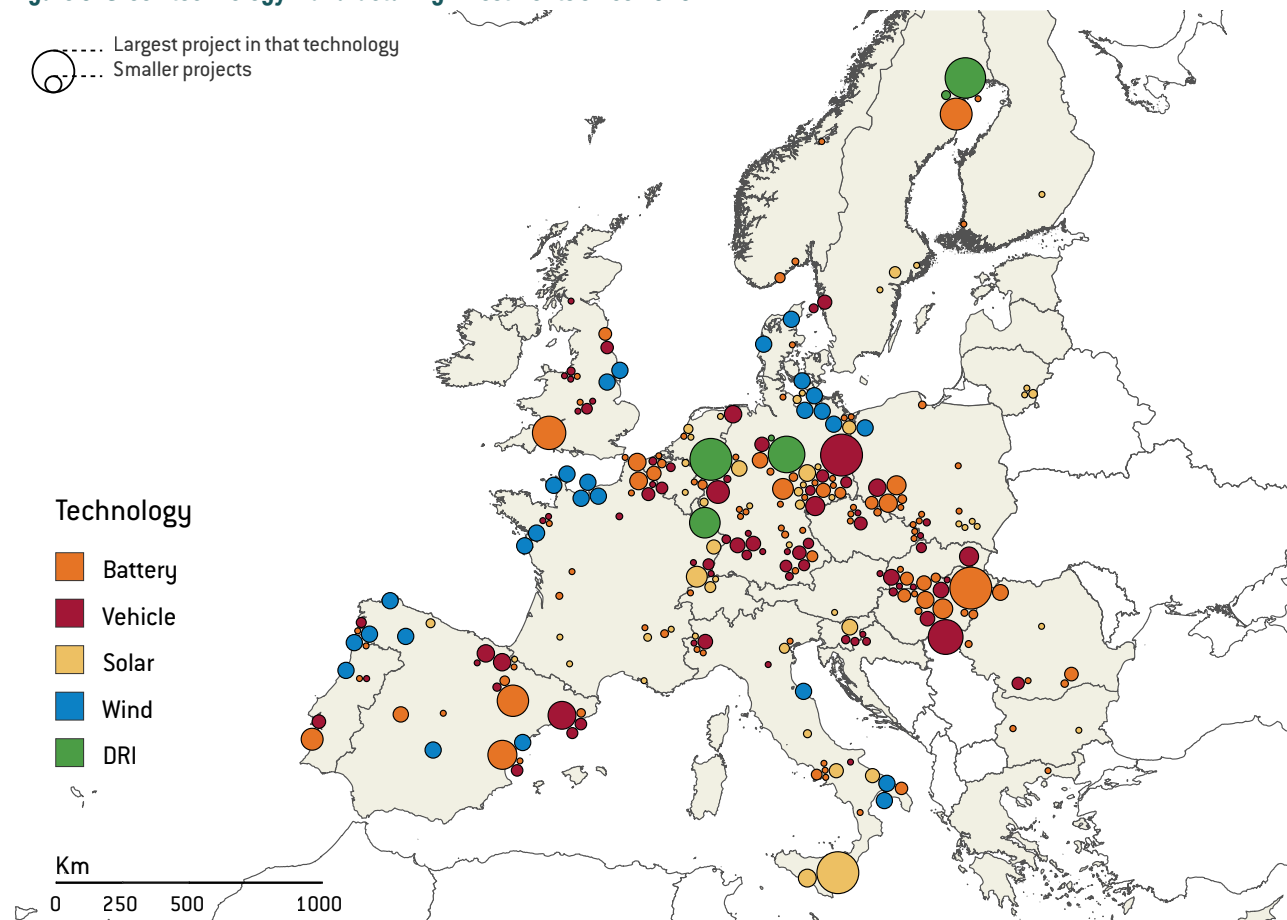
- *Complex with fewer new opportunities* (bottom right): countries in the bottom right quadrant, such as Germany and Czechia, are complex but have fewer new opportunities in green value chains. This is often because these countries already manufacture many products in these value chains, and so have limited space for diversification. Policy in these countries should focus on protecting competitiveness in the industries that exist already while innovating at the frontier to develop new industries.
- *Less complex with fewer opportunities* (bottom left): these countries are less complex and have fewer opportunities in green value chains. They should focus on strategic bets in new sectors to try and bring new capabilities into their economies. In Europe, these are largely small island states like Cyprus and Malta. France also appears in this grouping, possibly because it has less presence in the manufacturing-intensive clean-energy sectors that make up green value chains.

4 Regional positioning across green value chains

Economic information to identify clean-technology competitiveness is mostly available at national level. This is the case for the above sets of figures, which have been produced from trade data. However, competitiveness is determined by the collections of factories and people innovating and manufacturing within countries. Inevitably therefore, competitiveness has not only a national but a regional component. Cities and regions within countries specialise in different green value chains and industries.

Investment patterns offer an insight into these regional patterns. The Bruegel European Clean Tech Tracker (Bruegel Dataset, 2025) records €224 billion in investment in the battery, electric vehicle, green iron, solar and wind value chains in Europe since 2016 (Figure 6).

Figure 6: Green technology manufacturing investments since 2016



Source: Bruegel Dataset (2025). Note: an interactive version of the map is found at <https://europe-an-clean-tech-tracker.bruegel.org/investments/facilities>. Investments are sized relative to the largest from each technology, and do not represent exact euro amounts. For wind technology, data limitations mean all are a fixed size.

Wind manufacturing investment is concentrated along coastlines, often close to offshore windfarms to which such manufacturers provide products. Additionally, closeness to the coast provides access to port infrastructure important for the export of large wind towers and blades. Solar manufacturing investment meanwhile is more spread across Europe. Large investments were made in Germany, France and Spain during the first wave of European solar installations (around 2008 to 2011), although many plants have since shut down. The largest solar cell manufacturing plant today in the EU by capacity is on the Italian island of Sicily.

Battery manufacturing investments have emerged in clusters around the EU. The largest battery cell plant in the EU is in Wroclaw, Poland, operated by LG Energy. Since the factory was built in 2016, upstream and downstream investments have concentrated nearby. Similarly, Debrecen in Hungary has attracted a series of Chinese battery investments, alongside a BMW electric vehicle plant. In France, battery investment has concentrated in the Hauts-de-France region, with large investments from the European companies Verkor and Automotive Cell Company, and foreign companies AESC and ProLogium. These investments complement a Renault electric vehicle factory in Douai. A full interactive map of these investments is available via the European Clean Tech Tracker (Bruegel Dataset, 2025).

Most electric vehicle manufacturing investment has come from the retrofitting of internal combustion engine automobile manufacturing plants, suggesting a significant transfer of labour and capital from traditional automobile manufacturing to electric vehicle assembly. Large investments are therefore concentrated in Germany and eastern European countries including Slovakia and Czechia. Being able to access supplies of battery cells is an important new location factor. Hungary, for example, has attracted greenfield electric vehicle investments from BYD and BMW that build on major battery investments.

Production of primary (ie non-recycled) steel involves use of coal products to reduce iron ore, resulting in substantial greenhouse gas emissions. Reducing iron ore without these emissions is therefore a crucial step in decarbonising steel production. Doing so would produce intermediate green iron and involve large volumes of clean electricity (with the most promising route specifically involving the production of hydrogen from electricity). Accordingly, the most developed investment in Europe is Stegra's investment in northern Sweden close to hydropower electricity resources. Hydnum steel and Gravithy plan green-iron plants in southern Spain and France, respectively. Both are areas with above average solar irradiation that reduces the cost of solar electricity production. Other announced green-iron investments are alongside existing steel plants, including Salzgitter in Germany and ArcelorMittal in Dunkirk.

5 What should guide Europe green value chain investment?

Developing competitiveness in green value chains is a strategic priority for the EU. Doing so will better position Europe to enjoy economic growth as the green transition progresses. Greater green competitiveness will also offer economic security advantages arising from a shift in the balance of relative dependencies with third countries. From an economic-growth perspective, Europe should target industries that are both feasible and attractive.

Feasible industries are those for which Europe already has some capabilities or related industrial production. Economic research shows countries are more likely to diversify into related industries, in which they have existing capabilities (Hidalgo, 2023; Balland *et al*, 2022; Hausmann *et al*, 2022). For example, electric-vehicle manufacturing is more feasible in regions that have experience of automotive manufacturing in general, and wind turbine manufacturing is more feasible in areas that have histories of aerospace production (such as Brazil; Ereno 2010) owing to technical similarities between these activities (van Garrel *et al*, 2018).

Attractive industries are complex, involve products that fewer countries can produce, and bring new capabilities to European regions. These industries are typically higher value, involving the advanced industrial capabilities that can add value and sustain Europe's

high standard of living. They may also open new pathways for industrial diversification and economic growth in Europe. More-attractive industries therefore involve high value-added and complex activities such as the production of catalysts, gearboxes for wind turbines or novel, high-performance materials such as silicon carbide power electronics.

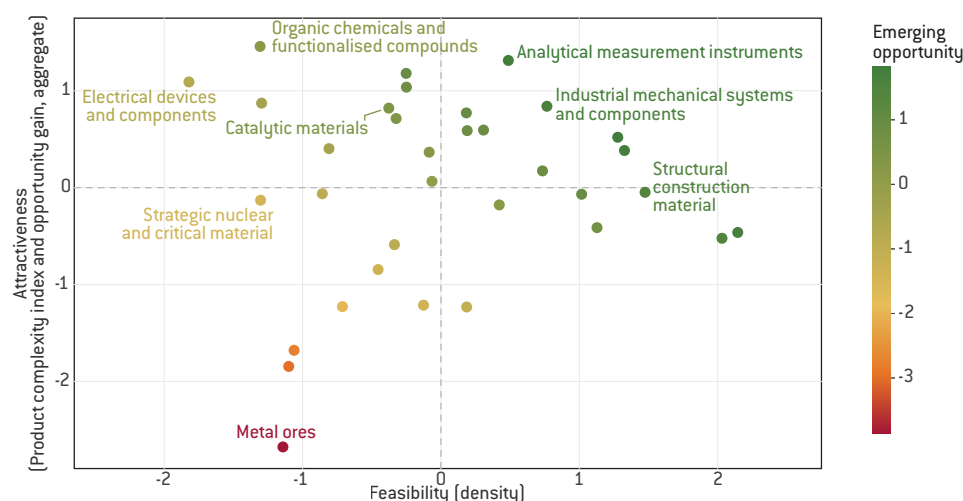
Policymakers may choose industries that are attractive for reasons other than their complexity, such as industries that are already large or growing quickly. There may at times be a trade-off between industries that are large and industries that are complex. Practically speaking, it is more useful for policymakers to target groups of industries that are generally complex, large and fast-growing, rather than focus too much on any single attractiveness metric, such as industry size, industry growth rate or industry complexity.

Figure 8 illustrates the feasibility and attractiveness of 34 green industrial clusters in Europe. These clusters are groupings of similar products that are used in green technologies, for which production tends to co-locate geographically.

The metric ‘feasibility (density)’ on the x-axis of Figure 8 represents feasibility: clusters with high density scores are related to Europe’s existing industrial production and Europe tends to have extensive productive capabilities in these sets of industries. The y-axis of Figure 7 represents attractiveness of different clusters using a composite score of the product complexity index and complexity opportunity gain, both of which are drawn from the economic complexity literature (Hausmann *et al*, 2014). Taken together, clusters that score highly on the y-axis involve complex products that can bring new capabilities and diversification pathways to Europe.

The most feasible and attractive industrial clusters for Europe to develop are those in the top right of Figure 7. This analysis suggests that European policymakers should aim to develop industries in sectors including composite fibres, technical polymers, catalytic materials, analytical measurement instruments and power-generation equipment: complex industries in which Europe has the right industrial capabilities.

Figure 7: Feasible and attractive green industrial clusters in Europe



Source: Bruegel. Note: Growth Lab (2025) replicates the above figure for each country in Europe and has further methodological information.

When targeting green industrial policy investments within Europe, European policymakers should focus investments in particular industries on those regions that offer the best fits for each industry, hosting industries in their most supportive industrial ecosystems. European regional economies are very diverse, specialising in different types of products and economic activities. Industries are more likely to be successful if embedded in a supportive cluster or ecosystem, with many nearby related economic activities (Delgado *et al*, 2014; Ellison *et al*, 2010). This is because similar industries can then draw on a shared core of capabilities, including a workforce with appropriate skills, suitable infrastructure, research and development activities and shared market conditions.

This logic underlies Europe's smart specialisation strategy, which aims to direct investment in particular regions to the industries in which those regions have competitive advantages or leadership positions. This strategy was adopted by EU legislation in 2013 (Regulation (EU) No 1303/2013), and has since played a role in the deployment of funds under European cohesion policy (Gianelle *et al*, 2020). Smart specialisation aims to build on each region's strengths to maximise commercial success, rather than to spread funds across a range of bets which don't all fit the recipient location particularly well. It aims to make efficient use of public funds by focussing on industries that can more easily connect to and be embedded in the industrial structure of a region (Boschma and Gianelle, 2014).

European policymakers should follow a similar approach when using public money to develop domestic green value chains. This approach offers the best path to success for Europe as a whole, even if it leads policymakers to prioritise some regions over others. Fortunately, green value chains encompass a wide range of diverse industries, and most European countries have at least some good opportunities within these value chains. The strongest European green value chains would knit together these diverse regional strengths.

Policymakers in Europe have other valid objectives. Cohesion policy, for example, aims to deploy public incentives to bring new capabilities and industries to lagging regions, pushing to generate economic development in left-behind places and creating new industrial hubs. However, green value chains are fiercely competitive, as befits manufacturing-intensive, fast-growing sectors into which East Asian manufacturing powerhouses have heavily crowded. For industrial policy to have the greatest chance of success in developing a competitive European industry, it will need to guide investment towards the regions most able to host it (Ahuja and Hausmann, 2025; Helveston *et al*, 2022).

6 Conclusion

Like many growth industries, green value chains are fiercely competitive. Despite having broad capabilities across these industries, Europe's competitiveness in green value chains is eroding modestly, broadly in line with other advanced industrial economies including the US and Japan.

This general trend masks broad variation in competitiveness, industrial specialisation

and opportunities in these industries across European countries. Some European countries are broadly competitive across large parts of these value chains, while most specialise in particular industries or clusters within these value chains. While many European countries are gradually losing competitiveness, some countries are improving their positions in these industries. And while the extent of the opportunities within these industries differs from country to country, most European countries have at least some potential in green value chains and industries.

Economic-complexity metrics suggest a set of green industrial clusters that offer the most feasible and attractive opportunities for Europe. Europe should invest to develop these industrial clusters in the locations that are most suitable for hosting them, consistent with the EU's smart specialisation strategy.

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