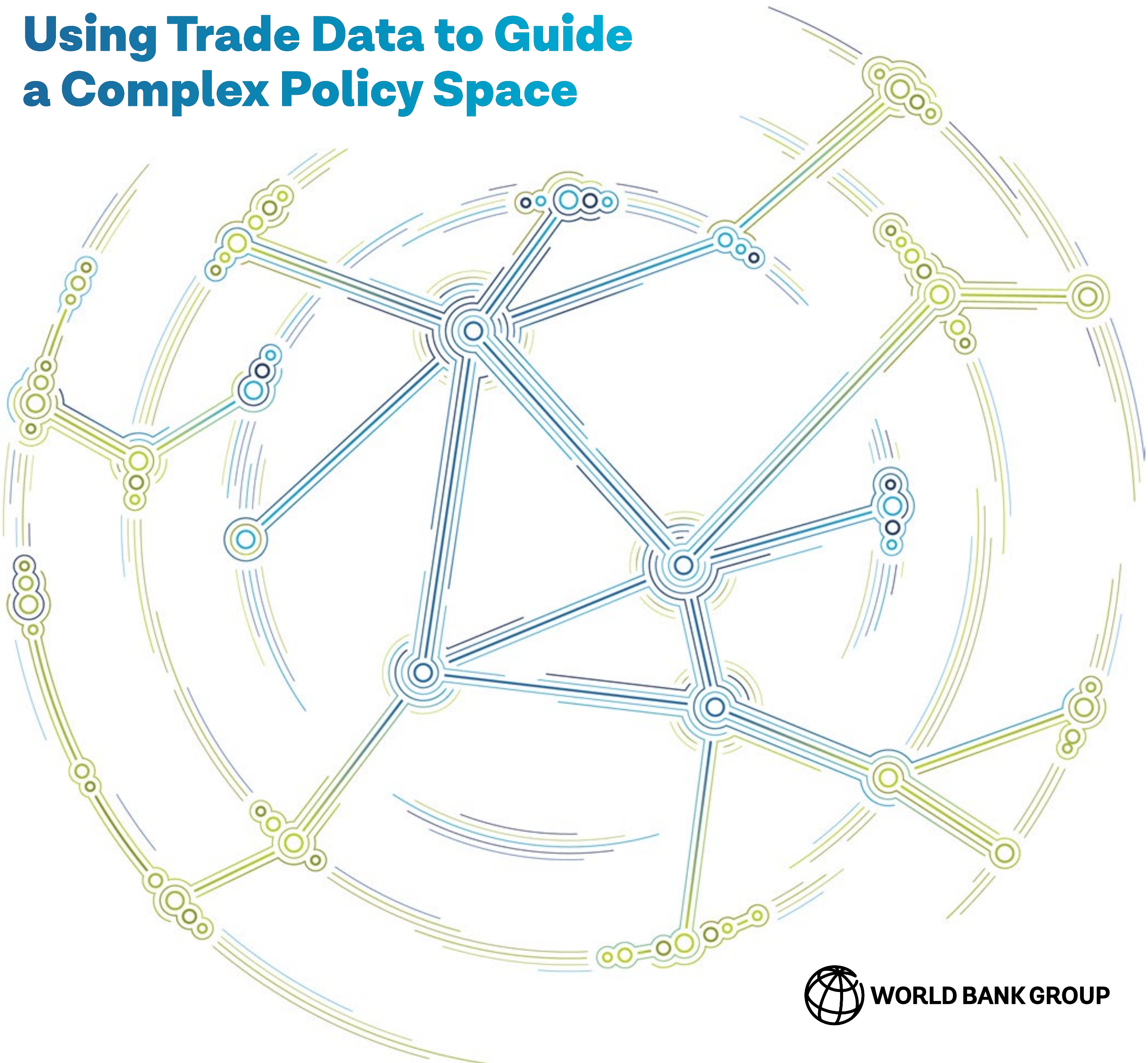
EU REGULAR ECONOMIC REPORT 10

WORLD BANK REPORT
ON THE EUROPEAN UNION

PART 2

# Clean Tech Value Chains

## Using Trade Data to Guide a Complex Policy Space



WORLD BANK GROUP

EU REGULAR ECONOMIC REPORT 10

PART 2

# Clean Tech Value Chains

## Using Trade Data to Guide a Complex Policy Space

WORLD BANK GROUP

1818 H Street NW
Washington DC 20433
Telephone: 202-473-1000
Internet: www.worldbank.org



**Cover design and typesetting:**
Piotr Ruczynski, London, United Kingdom, prucz.co.uk

# Contents

## Boxes



## Figures

## Tables

# Acknowledgements

The Part 2 of the 10th Edition of the World Bank Group EU Regular Economic Report was led by Emilija Timmis and Gregor Semieniuk (both Senior Economists at the EU Prosperity Economic Policy unit, World Bank) and produced by the following core joint World Bank — IFC team: Samuel Rosenow (Economist, IFC) and Sarur Chaudhary (Consultant) led the simulations for the EU export potential in the selected value chains in the 4 CEES; Anne Beck (Economist, World Bank), Gianluca Santoni (CEPII), Daria Taglioni (Research Manager, World Bank) led the firm network analysis, with inputs from Antonis Tsiflis (Young Professional, World Bank), who also conducted analysis of the investment impact of the global policy shifts, complemented by Pao Engelbrecht (Consultant) with work on regional policy review and state aid deployment analysis; Jade Salhab (Senior Economist, World Bank), Francisco Moraes Leitao Campos (Senior Economist, World Bank), Diana Hristova (Consultant), Robert Nowakowski (Consultant), Yohei Soma (Contractor) contributed the analysis of the factors driving the investment needs in the selected clean tech value chains; Marie Therese Kane (Consultant), R. Balaji (Chief Industry Advisor, IFC), Asogan Moodaly (Senior Investment Officer, IFC), Petros Shayanowako (Consultant), and Rubidium Data (Consultant), led intensive value chain mapping, building on previous efforts of Penelope Mealy (Senior Economist, World Bank) and Samuel Rosenow; Alen Mulabdic (Senior Economist, World Bank) conducted the analysis trade gravity modeling; Deborah Winkler (Senior Economist, World Bank) and Luis Alejandro Aguilar Luna (Consultant) provided the analytics on trade and jobs developments; Isabel Estevez (Senior Expert) led the work and advised on industrial strategy design. Leonardo Iacovone (Lead Economist, World Bank), Matias Belacin (Consultant), Fabian Scheifele (Young Professional, World Bank), Lukasz Marek Marc (Senior Economist, World Bank), and Matija Laco (Senior Financial Sector Specialist, World Bank) provided critical inputs and collaborative guidance throughout the preparation of this report; Ralf Martin (Principal Economist, IFC) and Dennis Verhoeven (KU Leuven) provided analysis on returns to innovation; Reka Juhasz (University of British Columbia) and Verónica C. Pérez (Boston University) provided data on industrial policy, analyzed by Vanessa-Paradis Olakemi Dovonou (Young Professional, World Bank); Ehab Tawfik (Research Analyst, World Bank) conducted multiple analyses on the 4CEE trade evolution and descriptives and provided exceptional research assistance. Marcello Arrigo (Consultant) edited the report.

Maryla Maliszewska, Enrique Aldaz-Carroll (both Senior Economists, World Bank), and Ralf Martin (Principal Economist, IFC) served as peer reviews for the report. In addition, useful comments were received from Country Teams, including: Catalin Pauna, Desislava Enikova Nikolova, Nathalie Picarelli, and Josip Funda, Andrzej Halesiak, Iva Tomic, Andrei Silviu Dospinescu, and Reena Badiani-Magnusson at various stages of production. The report benefitted from multiple insights from colleagues, including Antoine Coste, Chiara Criscuolo, Szilvia Doczi, William Hynes, Mariano Gonzalez, Mariem Malouche, Penelope Mealy, Katherine Stapleton, Collette Wheeler, among others.

Managerial guidance and direction were provided by Anna Akhalkatsi (Country Director, EU member states), Asad Alam (Regional Director, Prosperity, Europe and Central Asia), and Jasmin Chakeri (Practice Manager for Economic Policy, Europe and Central Asia). The analytics in this report have been supported by the Climate Support Facility Trust Fund.

# Abbreviations

**AI** Artificial Intelligence
**BPM5** Balance of Payments Manual, fifth edition
**BPM6** Balance of Payments Manual, sixth edition
**4CEEs** Four Central and Eastern European countries
**CCS** Carbon capture and storage
**CEE** Central and Southeast Europe
**$CO_2$** Carbon dioxide
**CCUS** Carbon capture, utilization and storage
**EC** European Commission
**ESPC** Energy Savings Performance Contracting
**EU** European Union
**EU27** European Union
**EV** Electric vehicles
**FDI** Foreign Direct Investment
**FSRU** Floating storage and regasification unit
**GDP** Gross Domestic Product
**GTA** Global Trade Alert
**GVCs** Global Value Chains
**GVCE** Green Value Chain Explorer
**HS** Harmonized System
**IEA** International Energy Agency
**IRA** Inflation Reduction Act
**IT** Information technology
**OAS** Onshoring attractiveness score
**OECD** Organisation for Economic Co-operation and Development
**OEMs** Original equipment manufacturers
**NZIA** Net Zero Industry Act
**PCI** Product Complexity Index
**PV** Photovoltaics
**R&D** Research and Development
**RCA** Revealed Comparative Advantage
**RER** Regular Economic Report
**SME** Small and medium-sized enterprise
**STEP** Strategic Technologies for Europe Platform
**TCTF** Temporary Crisis and Transition Framework
**US** United States
**US$** US dollars
**VC** Value chain
**WBG** World Bank Group

# Regional Groupings

**Four Central and Southeastern European ountries (4CEEs):**
Bulgaria (BG), Croatia (HR), Poland (PL), Romania (RO)

# Executive Summary

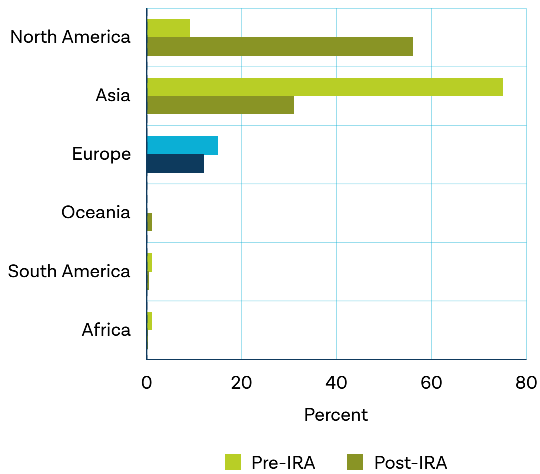
**As multiple crises erode the hard-won gains of inclusive growth, policy makers turn to the opportunities arising from the climate agenda to revitalise growth and job prospects.** For the world to reach net-zero emissions by 2050, the deployment of clean energy technologies[1] — such as solar photovoltaic (PV), wind turbines, electric vehicles (EVs), and heat pumps — must accelerate dramatically, with a resulting global market estimated to be worth trillions of euros per year. Developing export competitiveness in manufacturing products — particularly those that are more technologically sophisticated — has been linked to a wide range of economic benefits, such as higher economic and employment growth, productivity increases and technological upgrading.

**The EU and other large economies have recently announced significant policy shifts aiming to boost domestic production and innovation in specific sectors, including clean energy technologies.** Despite well-documented risks associated with targeting specific sectors, policy makers increasingly regard 'horizontal policies' (which aim to strengthen the economy overall without providing a direction) as necessary but not sufficient to address the challenges that their countries face around inclusion, competitiveness, resilience, or climate change. They look additionally to 'vertical' or 'targeted' policies that specifically aim to strengthen certain firms or sectors over others. Industrial policy — i.e., policy aimed at changing the structure of the economy in specific ways based on economic, security, geopolitical or other motives — is therefore making a comeback. and one of the targets is clean energy technologies.[2]

**Major policy shifts, aiming at actively directing the structure of the EU economy, are prompting its member states to rethink their national approaches so as to benefit from the potential opportunities.** The enactment of the Inflation Reduction Act (IRA) in the US has fueled the debate in Europe about boosting domestic manufacturing; moreover, shifts in Foreign Direct Investment (FDI) flows in sectors targeted by the IRA and related US legislation can be observed (Figure ES.1). Following the significant change in EU policies aiming to increase the domestic production of clean energy technologies (among other strategic products and critical raw materials), and the relaxation of state aid rules, member states are seeking to boost

**FIGURE ES.1 There were notable shifts in FDI flows in electronic components for environmental technology manufacturing after the announcement of the IRA.**

Share of FDI in electronic component manufacturing for environmental technology




*Source:* World Bank calculations using FT FDi Market data, Environmental Technology Cluster. Note: 'Pre-IRA' corresponds to January 2019 – August 2022; 'post-IRA' to September 2022 – November 2023.

1 In this report, products that either produce, store, or deliver low-carbon energy are referred to as 'clean energy technologies' or 'clean tech', as per the IEA's definition. The EU's nomenclature includes 'clean technologies', 'net zero technologies', and 'green technologies', among others. Per the emerging nomenclature, 'technologies' are intended as products — i.e., capital goods, consumer goods, and intermediate goods — not as 'productive' knowledge.

2 Criscuolo, C., et al. (2022a), "An industrial policy framework for OECD countries: Old debates, new perspectives", OECD Science, Technology and Industry Policy Papers, No. 127, OECD Publishing, Paris, https://doi.org/10.1787/0002217c-en. Juhasz, Lane and Rodrik (2024).

investment in their respective economies to benefit from opportunities in the new landscape. Notably, the EU's Net Zero Industry Act (NZIA) sets benchmarks for the domestic manufacturing of a wide range of products that produce or use clean energy, amounting to the equivalent of 40 percent of EU demand by 2030, and 15 percent of global demand by 2040.

**Amid the projected expansion of the market for clean tech under the NZIA, the opportunities for EU member states — including the 4CEEs — could be considerable.** Simulations based on fine-grained trade data show that the four Central and Eastern European countries (4CEEs) covered in this report — Bulgaria, Croatia, Poland, and Romania — could boost their exports in selected clean tech value chains mapped in this report, namely those for: electric vehicle (EV) batteries, heat pumps, wind energy, solar PV, and electrolyzers. Depending on their existing performance in the selected value chains, as well as demand, supply, and ease of market access, the 4CEEs could potentially triple their exports in clean tech value chains if they maintain their current market share; and quadruple them, or more, if the ambitious EU targets under the NZIA are achieved, all else being equal.

**However, a lack of coordination and funding at the EU level prompts a need for national initiatives, and risks causing divergence among member states.** Although the EU's Temporary Crisis and Transition Framework (TCTF) allows for state aid to strategic clean tech projects, the absence of bloc-wide coordinating mechanisms and funding for such efforts exacerbates the risk of uneven implementation and divergence among member states (well-covered in the recent The Future of European Competitiveness report led by Mario Draghi, and The Future of the Single Market report led by Enrico Letta). Elevated and uneven fiscal and policy capacity constraints across member states underscore such risks (notably, Poland and Romania must reckon with substantial but necessary fiscal consolidation). As a result, while EU policy offers an answer to the why of targeted efforts to reshore manufacturing for resilience and growth, the implementation of this agenda — the what and how — falls on national policymakers.

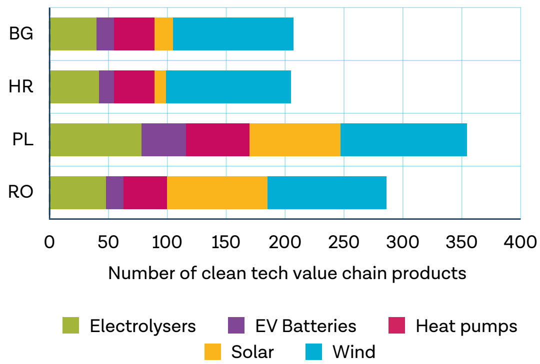
**The challenge of turning targeted EU policy into successful national and EU-wide economic outcomes requires careful analysis by national policymakers.** This entails considering what industries to target, and whether to target any at all. The EU emphasizes a strategic focus on 19 clean energy technologies, but in today's fragmented and complex value chains, understanding where a country may have a competitive edge that policymakers could potentially strengthen is key. National policymakers must also analyze how to administer support, choosing and combining policies from a broad toolkit that is not limited to subsidies — which are costly and have a checkered record, especially if not well coordinated with complementary polices. This analysis is inherently challenging, but it benefits from insight into the existing industrial structure and frameworks of each economy, as well as from an understanding of available state capacity.

**Emerging data and analytics can enhance the understanding of the existing policy space and the capabilities of each economy, which is critical to the design of successful horizontal or vertical policies.** Increasing economic complexity, and trade patterns that fragment the production of goods across countries, pose a growing challenge to the accurate tracking and assessment of any country's value addition in the production of complex goods. This report showcases how fine-grained trade and firm-level data, together with AI-enabled as well as traditional qualitative analysis, can yield insights into the 4CEEs' current participation in clean tech value chains, how their firms are linked to other firms abroad or at home, and what factors investors consider when deciding where to manufacture clean tech.

**The 4CEEs already participate in clean tech value chains, albeit to a varied degree and across different segments.** Careful — if not caveat-free, especially as the measures rely on gross trade data — mapping of the five clean tech value chains and using fine-grained data shows that 4CEEs showcase considerable export competitiveness and face robust export growth rates in some of the selected value chains (Figure ES.2). This signals their potential to capitalize on the transition to the green economy — with differences stemming from their respective economic structures. The 4CEEs tend to focus on subcomponents and products of medium complexity, pointing to growing sophistication and a mid-tier positioning in the value chains considered. However, the diverse mix of products and stages of production linked to clean tech value chains in these countries highlights the difficulty of appropriately devising targeted policies.

**FIGURE ES.2 Number of clean tech value chain products, by 4 CEE exporter**

Unique value chain components with high onshoring attractiveness score (Exports to other EU countries).

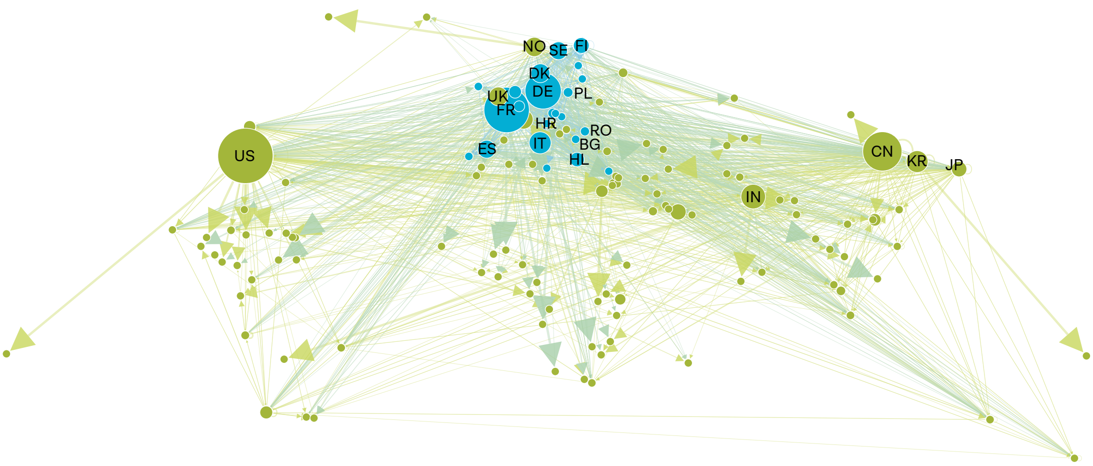



*Source:* World Bank calculations.

**EU firms, including those in the 4CEEs, are highly integrated into global clean tech value chains, highlighting risks from inward-looking policies** (Figure ES.3). Firm network analysis in the selected clean tech value chains considers firms' links to their buyers and suppliers around the world, and their position in the value chain. Among the 4CEEs, Poland emerges as an important intermediary in clean tech value chains, while firms in Croatia and Bulgaria tend to operate in less connected islands. Poland and Romania have large domestic supplier bases, showing greater potential for job creation, policy impact, and investment attraction. In contrast, Bulgarian and Croatian firms in clean tech value chains import most or all of their inputs, highlighting limited integration with the domestic economy and pointing to the complementary importance of horizontal policies.

**FIGURE ES.3 Global clean tech value chains are closely intertwined**

Network representation of buyer-seller relations, country aggregates, global level




*Source:* World Bank calculations using FactSet.

*Note:* Blue nodes represent EU buyers/suppliers, green nodes — non/EU buyers/suppliers. The arrows indicate the direction of the buyer-seller relationships, with the thickness of the arrows representing the relative importance of the supplier's country of origin to the destination country. The size of each node reflects the betweenness centrality (i.e. the number of shortest paths through the node).

**When making investment decisions in clean tech value chains, private investors report considering multiple factors, including but not limited to government incentives.** The scale-up in production necessary to drive scale-up in exports requires substantial upfront investment — particularly from the private sector. For the five clean tech value chains considered, achieving export volume scale-up in line with simulations based on EU policy targets would require estimated investments in manufacturing of between US$1 billion (in Bulgaria, Croatia, and Romania) and US$5 billion (in Poland). While government incentives are certainly on the radar of potential investors, targeted surveys show that equipment manufacturers prioritize factors such as supplier network strength, availability of skilled labor, and R&D ecosystems. On the other hand, project developers (i.e., the buyers of clean tech products, e.g. for a wind farm or hydrogen production facility) focus more on regulatory clarity, government incentives, and ease of licensing (Table ES.1).

**An EU-level strategy that coordinates priorities across member states and considers place-based industrial policies could benefit the 4CEEs and all other member states.** The analysis in this report points to a risk that all member states attempt to onshore the same industry, prompting a race to the bottom. To help avoid such an outcome, the EU could, at a minimum, take on a coordinating and information-sharing role. A more proactive stance would be possible too, and could benefit from the extensive literature on place-based and regional industrial policy. Place-based industrial policy aims to locate an industry in a particular place based on uneven eligibility by place or region, and the EU already has ample experience with cohesion programs in other policy areas. Moreover, there is evidence that such place-based policies work well in tandem with specific member states polices, one example being local or national investment promotion agencies. The 4CEEs, especially Bulgaria, Croatia and Romania would stand to benefit particularly from place-based industrial policy at the EU level, based on the evidence in this report.

**TABLE ES.1** Incentives are on the radar of investors in clean tech, but not at the top of their list

| Driver (ranked) | Bulgaria | Croatia | Poland | Romania |
|---|---|---|---|---|
| 1. Market Size and Prospective Trends | Low | Medium | High | Medium |
| 2. Energy Costs | Medium | High | Medium | High |
| 3. Labor Cost/Availability | Medium | High | Medium | Medium |
| 4. Connectivity and Infrastructure Quality | Low | High | High | Medium |
| 5. Ease of Obtaining Licenses | Medium | Medium | High | High |
| 6. Direct Government Incentives | Medium | Medium | High | Medium |
| 7. Supplier Network Strategy | Low | Medium | High | Medium |
| 8. Technology and Innovation Ecosystem | Medium | High | High | Medium |
| 9. Cost/Availability of Land or Infrastructure | Low | Medium | Medium | Medium |
| 10. Climate Resilience | Low | Low | Medium | Medium |

High: Strong presence and favorable conditions
Medium: Moderate presence and somewhat favorable conditions
Low: Weak presence and less favorable conditions

# Introduction and context

# The global rise of targeted policies for the green transition

**Policymakers around the world have been increasingly seeking to actively shape the structure of their respective economies to respond to major challenges.** Be it inclusion, competitiveness, resilience, or climate change, there is increasing conviction in policy circles that efforts to strengthen the economy overall without providing a specific direction (so-called horizontal policies) are necessary but not sufficient to address these challenges.[3] Instead, policymakers have additionally been deploying vertical or targeted policies that specifically aim to strengthen certain firms or sectors over others.[4] Industrial policy, aimed at purposefully changing the structure of the economy based on economic, security, geopolitical, or other motives, has been making a comeback.[5]

**Industrial policies are controversial because of the risk of poor design.** There are well-known challenges around designing industrial policy.[6] Governments need significant information and expertise to decide which targets to set, for what purpose, and for which industries. The decision-making process can be captured by special interests, with firms and sectors likely to lobby for preferential treatment. Sunset clauses are necessary to define when and under what conditions (e.g., failure to achieve a target) the support will stop. Targeting some industries over others may present opportunity costs in forgone growth and/or employment in other sectors that may (or may not) yield higher returns to public subsidies. A re-emerging body of literature[7] provides an overview of the industrial policy toolkit and evaluates more and less successful examples.

**With the ambition of the climate change mitigation agenda and the rise of corresponding market opportunities and strategic considerations, 'green' industrial policies, strategies, and plans are also on the rise.** In general, 'green' industrial policy can refer to any industrial policy that advances climate change mitigation or environmental sustainability more broadly. In this report, the term refers specifically to those policies encouraging the production of capital goods and consumer durables required to supply and use low-carbon ('clean') energy. Mitigating and adapting to climate change requires major investments in new capital goods and consumer durables to decarbonize the economy, such as solar photovoltaic (PV) panels, wind turbines, batteries for electric vehicles (EVs) and heat pumps. These products either produce, store or deliver low-carbon energy, or are able to use it — typically in the form of electricity. The manufacturing of clean energy technologies,[8] a catch-all term for these products, represents an estimated global growth market worth trillions of US dollars (US$) a year (Figure I.1).[9] The countries that can supply these global markets have an opportunity to revitalize their growth and job prospects. Green industrial policy aims to create competitive advantages to get a larger share of that supply, and has been deployed by the world's major economies. China has maintained ambitious industrial policy targeting clean energy technologies since at least its 12th five-year plan (2011 – 2015). Following the increasing regional concentration of clean tech manufacturing, there have been substantive policy

3 Criscuolo, C., et al. (2022a).

4 Criscuolo, C., et al. (2022) defines horizontal policies as available to all firms, irrespective of their activity, technology or location, e.g. R&D tax credits or (economywide) carbon pricing. Vertical policies must be restricted to a subset of firms, based on their activity, technology or location, e.g. public procurement. Part of the literature labels horizontal policies as 'industrial policies' too, not least because even policies available to all firms tend to be taken up more by subsets of sectors/firms, see Reed (2024).

5 Criscuolo, C., et al. (2022); Juhasz, Lane and Rodrik (2022), Stiglitz, Lin and Monga (2013).

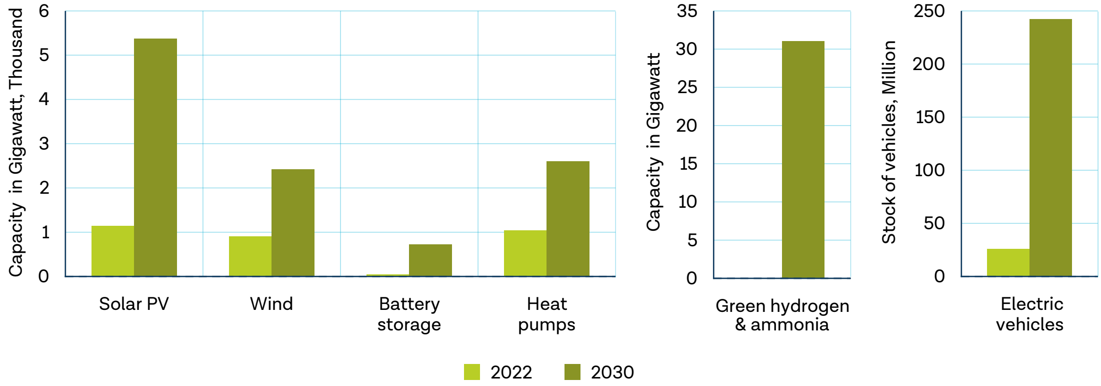
6 Criscuolo, C., et al. (2022).

7 Including but not limited to: Juhasz, Lane and Rodrik (2024), Estevez (2024), Hidalgo (2023), Criscuolo, C., et al. (2022a)., Cherif and Hasanov (2019), and earlier Amsden (1989), and Chang (1996), among others.

8 For the purposes of this report, products that either produce, store or deliver low-carbon energy will be referred to as 'clean energy technologies' or 'clean tech', in line with the IEA's definition. The EU nomenclature includes 'clean technologies', 'net zero technologies', 'green technologies', among others. In line with the emerging nomenclature, 'technologies' refers to products (capital goods, consumer goods and intermediate goods), and not 'productive' knowledge.

9 IEA (2023). World Energy Outlook 2023. Paris, International Energy Agency.

**FIGURE I.1** **Global cumulative manufacturing capacity for selected clean energy technologies in 2022, and a 2030 scenario in which governments fulfill their stated decarbonization pledges**



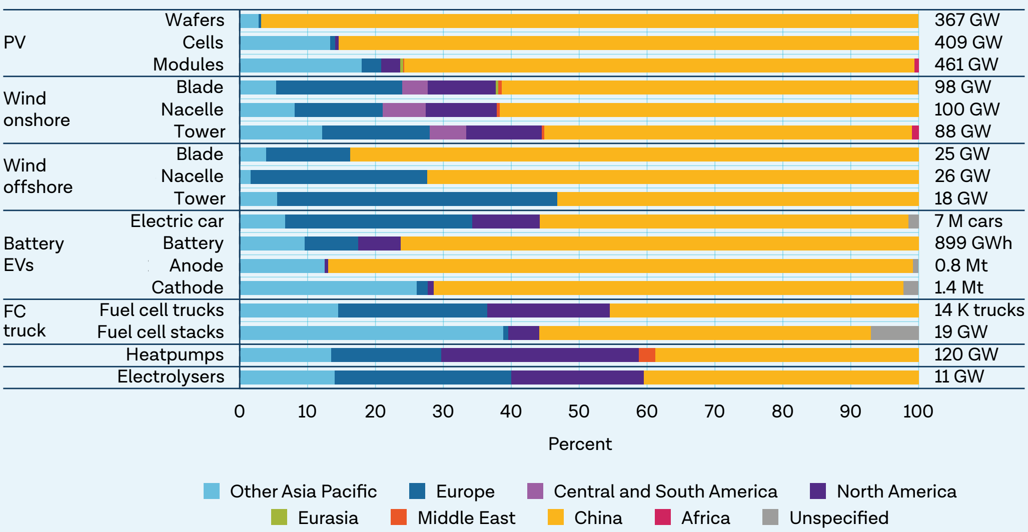

*Source:* Data from IEA, World Energy Outlook 2023; IEA, "Renewables 2023 Analysis and forecast to 2028"; IEA, "The Future of Heat Pumps", World Energy Outlook Special Report, 2022; IEA Global EV Data Explorer. 2030 data is from the IEA's announced pledges scenario, which projects deployment if governments fulfill their own pledges up to 2030 (e.g., the EU's Fit for 55). Historical data for heat pumps is from 2021, for batteries from 2020.

shifts in North America (Box I.1) and the EU (discussed below and in Box I.1). In 2022, the US passed the Inflation Reduction Act (IRA), which offers unprecedented subsidies partly conditional on local content to clean energy product manufacturers. This has had consequences on foreign direct investment (FDI) flows across regions — see Box I.1.

### BOX I.1 Clean tech manufacturing investments respond to industrial policy

**The manufacturing of clean energy technologies has been increasingly regionally concentrated.** Around 90 percent of mass-manufacturing capacity for multiple clean energy technologies is based in the East Asia and Pacific region, and especially in China (Figure BI.1.1).

**FIGURE BI.1.1** **Regional shares of manufacturing capacity for selected mass-manufactured clean energy technologies and components, 2021 (IEA)**



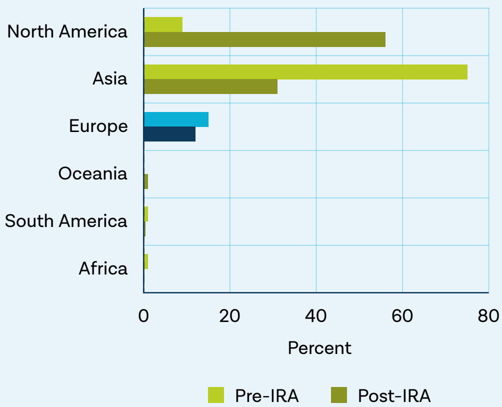

*Sources:* IEA, Energy Technology Perspectives, 2023, based on InfoLink (2022); BNEF (2022); BNEF (2021b); Benchmark Mineral Intelligence (2022); GRV (2022); UN (2022a); Wood Mackenzie (2022).

*Notes:* FC = fuel cell. Heat pumps capacity refers to thermal output.

**In 2022, the US passed the Infrastructure Investment and Jobs Act and the IRA, which together amount to an unprecedented industrial policy boost to clean energy tech sectors in the world's largest economy.** The IRA will allocate an estimated US$370 billion or more in public funds over a decade to foster the domestic production of clean energy and related infrastructure and equipment. This includes 'vertical' policy levers such as grants, guarantees, tax credits for private companies and incentives for households, largely conditioned on using technologies made in the US (or in some cases in countries with which it shares a free trade agreement).

**FIGURE BI.1.2 Shifts in FDI flows in electronic components manufacturing after the announcement of the IRA**

Share of FDI in electronic component manufacturing for environmental technology




*Source:* World Bank calculations using FT FDi Market data, Environmental Technology Cluster. Note: Observations in the top 0.1 percent of capital have been dropped to account for some outlier investment; the results are not sensitive to this. 'Pre-IRA' corresponds to January 2019 – August 2022; 'post-IRA' to September 2022 – November 2023.

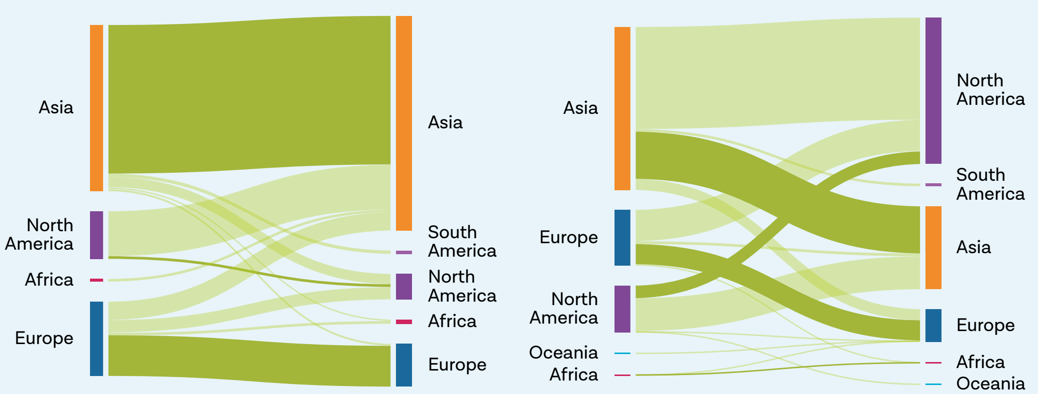
**The IRA has prompted visible shifts in FDI flows toward the US in some of the targeted sectors.** While FDI flows can be bulky and volatile, FT FDi data (2019 – 2023) points to sizeable shifts in FDI investment flows. Comparing the data 'pre-IRA' (January 2019 – August 2022) and 'post-IRA' (September 2022 – November 2023), there is evidence of change in the shares of investment flows towards North America in one of the targeted sectors: electronic component manufacturing for environmental technologies. Prior to the IRA, 75 percent of cross-border investment into this sector was flowing to Asia, with only one-tenth going to North America. In the year after the IRA's announcement, North America's share rose to over 50 percent, and Asia's share more than halved to 31 percent (Figure BI.1.2). Europe's share of cross-border investments in electric component manufacturing for environmental technologies remained relatively unchanged in the first year after the IRA.

**There is also a notable shift in the destination of cross-border FDI investment flows.** While prior to the IRA, the biggest flows in electronic component manufacturing for environmental technologies were observed within Asia, followed by those within Europe (Figure BI.1.3, panel a), post-August 2022 the largest share of newly announced investments in the sector originating from Asia and Europe was directed to North America (Figure BI.1.3, panel b).

**FIGURE BI.1.3 Shifts in the origin and destination of cross-continental investment**

a. Cross-continental investment flows (pre-IRA, Electronic components, manufacturing)

b. Cross-continental investment flows (pre-IRA, Electronic component, manufacturing)




*Source:* FT FDi Market data, Environmental Technology Cluster. Note: Observations in the top 0.1 percent of capital have been dropped to account for some outlier investment; the results are not sensitive to this. 'Pre-IRA' corresponds to January 2019 – August 2022; 'post-IRA' to September 2022-November 2023.

# The objective of this report

**This report aims to provide an overview of potential opportunities to participate in clean tech value chains, using new and evolving analytical tools from the World Bank Group that may help inform national policymaking around the EU's targets for clean tech manufacturing.** The focus is on four countries in Central and Eastern Europe (4CEEs): Poland, Romania, Bulgaria and Croatia. Given the strategic sectoral priorities set by EU policy, a central question concerns where within these sectors (and their EU value chains) the 4CEEs are already competitive or close to it, and have the potential to upgrade their prospects for growth and job creation as these value chains develop. Specifically, this report aims to:

- Take stock of key recent EU policy shifts;
- Provide a brief overview of recent export trends and their importance to job creation in the 4CEEs;
- Simulate the potential size and identify the specific segments of export opportunities in the clean tech value chains for the 4CEEs, by leveraging economic complexity analysis and mapping additional value chains;
- Provide an overview of existing cross-border connections in selected green supply chains for firms in the 4CEEs, using network analysis;
- Isolate the country-level factors that potential investors in the 4CEEs consider when deciding on investments in the production or deployment of clean tech, via interviews with a targeted sample of relevant investors;
- With the analytics at hand, and accounting for their limitations, provide an overview of the type of questions that national policymakers face.

**The report focuses on trade.** First, with relatively small domestic markets, 4CEEs firms seeking to grow in specific industries with a much larger international market (including the rest of EU) need to be able to export; thus, industrial strategies aimed at productivity and sectoral growth need ultimately be export-oriented.[10] Second, evidence shows that exporters tend to be more productive,[11] and that they drive domestic overall productivity and competitiveness.[12] Third, trade has been the most important avenue for growth and employment creation in all 4CEEs in the past (Box I.4), and industrial and trade policies are intertwined.[13] Finally, trade data tends to be available at a more fine-grained levels than domestic production data.

**Clean energy technologies are only one part of the toolkit for 'greening' the economy.** As noted above, this report focuses on a set of products categorized as clean energy technologies and their value chains, which mirror the 'net-zero technologies' as defined by the EU's Green Deal Industrial Plan. However, climate change mitigation and adaptation policies will induce broader structural change in the economy, and 'green value chains' encompass a much broader category of products. Every sector will have to play its role in 'greening' the economy, and will use (but not necessarily produce) net-zero technologies. Energy-intensive manufacturing or transport are two examples. More broadly, there is a drive to

10 Reed, (2024).

11 Wagner, (2007), Bernard and Jensen, (1995).

12 Atkin et al. (2019).

13 Juhasz et al. (2022).

produce goods and services in the economy in more energy-efficient and environmentally sustainable ways, which is not covered within the scope of this report.

**The report does not aim to assess the merits and direction of the EU's Green Deal Industrial Plan.** Critical discussions of the specific focus, implementation, and overall sensibility of a net-zero technology-focused industrial strategy can be found in the academic literature. Instead, this report takes the EU policy stance as a given, and looks at the opportunities it may open for its (selected) member states to participate in new (or growing) value chains.

Chapter 1

# The EU Green Deal Industrial Plan and its impact on member states

# The EU's green industrial policy response

**The EU introduced ambitious bloc-wide green industrial policy targets and instruments in 2023, in the wake of the IRA, and there are calls for more to be done.** The Green Deal Industrial Plan, announced in January 2023, and subsequent legislation set ambitious targets for domestic manufacturing of clean energy technologies and training of the workforce, introduced a streamlined project approval process (via the Net Zero Industry Act), and relaxed state-aid rules to enable the achievement of green targets (via the Temporary Crisis and Transition Framework) — see Box 1.1. While the targets are not binding, tariffs on electric vehicles and the recent *Future of European Competitiveness* point to appetite for more ambitious investment and local content stipulations.

**The recent EU policy shifts are likely to re-direct investment flows across EU member states, with repercussions for their export competitiveness.** As EU member states, the 4CEEs are well integrated in the EU single market, their trade patterns in 4CEEs are increasingly shaped by the EU, with a majority of their goods exports — across increasingly complex value chains — flowing to the rest of the EU (Box 1.4). These patterns evolved within a relatively stable policy framework, focused on horizontal policies, such as non-sector specific R&D subsidies. However, the recent legislation under the Green Deal Industrial Plan sets production share targets and allows state aid for projects advancing the manufacturing of net-zero (or clean energy) technologies–quintessentially 'vertical' industrial policies (see Box 1.1). This could have far-reaching consequences for investment and trade flows within the EU, including for the 4CEEs.

### BOX 1.1 European Union legislation for boosting domestic net-zero (or clean energy tech) manufacturing

**In recent years, the European Union has legislated in support of domestic manufacturing where it contributes to meeting the decarbonization of energy supply.** Key legislation includes the following:

- **The *European Green Deal Industrial Plan (GDIP)* was announced in 2023, as the broad framework for guiding and supporting the European industrial sector in the transition to net zero.** Its four pillars comprise the creation of a predictable and simplified regulatory environment, faster access to funding, net-zero compatible skills development, and resilient supply chains.
- **The *Net Zero Industry Act (NZIA)* (Regulation 2024/1735) aims to enhance European manufacturing capacity for net-zero technologies and their key components by setting production targets and addressing barriers to scaling up manufacturing in Europe.** The target is for net-zero manufacturing capacity to reach or approach at least 40 percent of the EU's annual deployment needs by 2030 and 15 percent of global capacity by 2040. Net zero technologies which fall under this target include solar PV, wind, batteries, heat pumps and electrolyzers among other renewable energy production and conversion technologies as well as nuclear fission, carbon capture and storage (CCS), electricity grids and energy efficiency related to energy systems (see Table 1.1 and the appendix). In addition, the NZIA covers the decarbonization of energy-intensive industries where they contribute to producing net-zero technologies. Barriers are addressed through measures to reduce administrative requirements, including the establishment of a single point of contact, tightening processing times, the streamlining in industrial clusters (net-zero acceleration valleys), and a Net-Zero Europe Platform for coordination; and by fostering workforce training in 'net-zero academies'. Promoters of investments into manufacturing of net-zero technologies can apply for their plans to be recognized as 'strategic net zero projects' to benefit from fast administrative processing and permitting. The application window started in July 2024.
- **Where the NZIA provides targets and administrative simplification, the *Temporary Crisis and Transition Framework (TCTF)* (2023/C 101/03) ensures that member states can subsidize manufacturing investments.** Originally created to allow state-aid in crisis-ridden sectors as a result of the Russian Federation's 2022 invasion of Ukraine, and initially called the Temporary Crisis Framework (TCF), the TCTF expanded the eligible state aid to ensure the transition to net-zero and the eligibility period until the end of 2025. The part relating to net-zero technologies (section 2.8) allows to support private investments with 'strategic importance for the transition to net zero', and lists a subset of NZIA technologies, namely solar, wind, batteries, heat pumps, electrolyzers and CCS, as well as their components and materials. The support may take the form of grants, capped at EUR150m

per project (or 15/35 percent of project cost for large/small firms), but rising up to EUR350m per project (or 35/55 percent for large/small firms) in assisted regions, so-called a-areas. It may also take the form of loans, guarantees or tax credits. For these forms of support, the subsidy caps are 5 percentage points higher than for grants. Higher subsidies are possible where they prevent the relocation of the investments to countries outside the EU.

- **Although the NZIA and TCTF set targets and allow state aid, they do not provide funding. The *Strategic Technologies for Europe Platform (STEP)* (Regulation 2024/795) aims to mobilize funds for critical technologies in order to reduce the EU's strategic dependencies and ensure competitiveness of its manufacturing industries.** The strategic net zero projects under the NZIA are included among these critical technologies and thus qualify for funding. However, to date the STEP does not offer new funds and only repurposes existing ones. Thus, beyond funding through the 'green transition' area of the Recovery and Resilience Facility, which is being used for this purpose e.g. to help fund battery and solar panel production investments in Romania[a] and which runs out in 2026, there are no dedicated European-level funds to pay for subsidies. As a result, what gets funded with subsidies depends on the willingness and ability of member states.
- **The *Critical Raw Materials Act* (Regulation 2024/1252) complements the NZIA with a focus on strengthening the supply of certain materials — raw and processed — deemed critical for the transition.** The present report mainly focuses on value chain segments covered by the NZIA mainly because critical raw materials are mined outside the EU.

a. https://ec.europa.eu/commission/presscorner/detail/en/ip_23_902

## Where does this leave the 4CEEs member states?

**While the EU strategic sectors are listed in the NZIA and the related legislation, they remain broad, in line with the breadth of objectives and technologies available for decarbonizing the energy sector, necessitating further selection at the member states level.** With the regional objectives guided by multiple factors across security, geopolitical, climate, economic and social objectives, and with multiple technologies available to meet energy decarbonization objectives, the selection of strategic industries is correspondingly broad (Table 1.1). Furthermore, the increasing complexities of the global value chains (GVCs) allowing countries to tap into them by producing sub-components rather than end goods (see chapter 2) may allow tapping into multiple value chains at various stages of production, multiplying the opportunity space. Thus, understanding productive (and/or exporting) capacities and constraints at the national level is crucial if considering an industrial strategy.

**TABLE 1.1** EU Strategic net-zero green technologies in the NZIA include a long list of broad sectors

| EU Strategic net-zero green technologies in the NZIA include: |
| --- |
| Solar photovoltaic and solar thermal technologies |
| Onshore and offshore renewable technologies |
| Battery/storage technologies |
| Heat pumps and geothermal energy technologies |
| Hydrogen technologies, including electrolyzers and fuel cells |
| Sustainable biogas/biomethane technologies |
| Carbon capture and storage (CCS) technologies |
| Grid technologies[a] |

*Source:* https://single-market-economy.ec.europa.eu/industry/sustainability/net-zero-industry-act_en

a. The NZIA also includes: Nuclear fission energy technologies, including nuclear fuel cycle technologies; Sustainable alternative fuels technologies; Hydropower technologies; Other renewable energy technologies; Energy system-related energy efficiency technologies, including heat grid technologies; Renewable fuels of non-biological origin technologies; Biotech climate and energy solutions; Other transformative industrial technologies for decarbonization; $CO_2$ transport and utilization technologies; Wind propulsion and electric propulsion technologies for transport; Other nuclear technologies. The Act also covers manufacturers in energy-intensive industries like steel, chemicals, and cement that produce components used in net-zero technologies and invest in decarbonization. https://single-market-economy.ec.europa.eu/industry/sustainability/net-zero-industry-act_en

**With the net-zero technology-focused EU policy, the 4CEEs are more protected from the rest of the world, but they stand in an increased competition with the rest of the EU.** As traditional supply chains — such as automotives — come under pressure, the 4CEEs may benefit from the drive to 'onshore' net-zero (or clean energy) technology value chains onto EU territory. That sets them apart from the competition outside the EU, especially if the targets are followed by more explicit local content rules, as some have argued for.[14] On the other hand, they stand in renewed competition with all other EU member states: there is no provision for the distribution of the new industries within the EU, nor effective coordinating mechanisms or joint funding. As a result, it is left to each member state to respond to the new legislation. Furthermore, when designing their response, the policy makers need to consider what the opportunity costs are and if the funds used could have been spent in more effective way (see Box 1.2 for some considerations and emerging evidence), especially in increasingly fiscally constrained setting.

### BOX 1.2 Emerging research point to limited opportunity cost to subsidies for clean tech innovation

**Identifying opportunities in specific industries within clean tech is a challenge, but there is also the broader question of whether clean tech as a whole is the most promising candidate for vertical policies.** Developed economies grapple with a dual challenge: reversing the trend of stagnating growth due to a productivity slowdown and cutting carbon emissions to tackle climate change. While the clean tech manufacturing may present opportunities for investment, production, and/or exports, choosing to support it comes with the opportunity cost of foregoing growth from supporting other sectors. A focus on clean technology may lead to a relative deprioritization of other sectors, which may (or may not) have higher returns to such financial support.

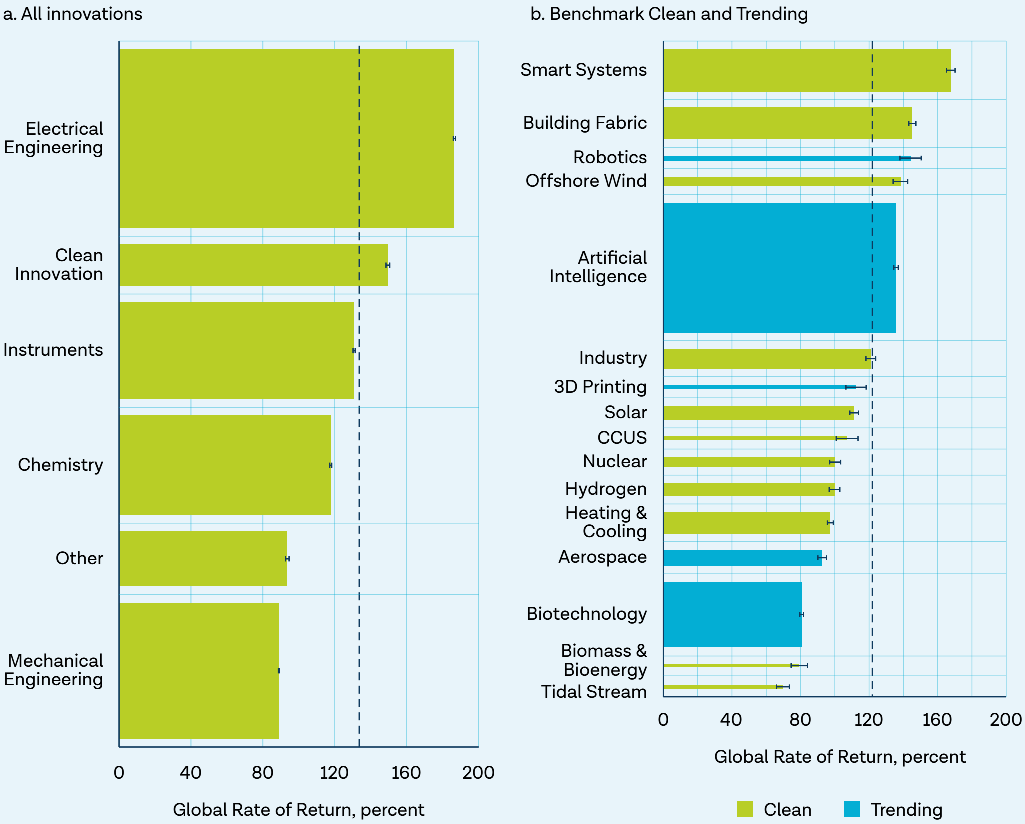
**While comparisons of returns to industrial policies by sector are hard to come by, more evidence is available at the 'upstream' research and innovation support level.** Recent research[a] evaluates the (social) rates of return to subsidies for R&D (i.e., innovation) across different sectors, distinguishing between the local (or country-level) rates of return (recognizing that subsidies are administered and funded at the national level) and global rates of return (capturing the spillover effects across borders), using citation data between patent families.

**Globally, clean tech generates among the highest rates of returns once knowledge spillovers are taken into account; and within Europe the clean subsidy advantage is even larger when comparing national returns alone.** The analysis finds that, globally, with a return rate of 135 percent clean technology ranks second among six broad fields, falling behind only to Electrical Engineering (Figure B1.2.1 a). 135 percent means US$ 100 invested in R&D subsidies generates US$ 135 in value. The weighted average return rate across countries and sectors is 120 percent, indicating that a subsidy scheme focused on clean tech generates roughly one-eighth higher returns than a uniform scheme that allocates subsidies proportionally to field sizes. Within the clean tech category, fields such as Smart Systems and Offshore Wind outperform others, exhibiting return rates exceeding those in Artificial Intelligence and Biotechnology (Figure B1.2.1 panel b). While based on national (within-Europe) returns, the clean subsidy advantage is — by definition — lower than that based on global returns, the localized relative returns for clean technologies are higher. Thus, a purely European planner would have an even stronger incentive to favor clean over other technologies than a global planner.

**The international spillovers also caution against hawkish responses to subsidies elsewhere, at least at the innovation stage.** The research[b] also shows that clean tech subsidies in the US yield substantive knowledge spillovers to the EU. Comparing cross-border returns for innovation in several major regions for the period 2009 – 2018, the authors find that US$ 1 million clean subsidy in the US would have resulted in US$ 1.26 million worth of spillovers in the EU, indicating that Europe benefits strongly from clean innovation support in the US, and more so from support targeted at clean rather than other technology areas. However, whether such knowledge spillover effects outweigh the potential costs of lost business remains an open question.

14 EU Future of Competitiveness report.

**FIGURE B1.2.1** **Global returns to R&D subsidies — weighted averages across countries**




*Source:* Martin and Verhoeven (2023).

*Notes:* Expected return rates to R&D subsidies by technology field (y-axis) along with 95 percent confidence bands. The (vertical) width of a bar indicates the field size, measured by its number of innovations. The x-axis displays the return rate (in percent) to an additional $1 of R&D subsidy in the field, with returns based on the spillover value that subsidy-induced innovation creates globally between 2009 and 2018. The left-hand figure includes the entire sample of innovations, divided into Clean and 5 other broad sectors. The right-hand figure compares sub-fields within Clean (see Martin and Verhoeven (2023) for a detailed description) to several trending technology fields. The dotted line represents the weighted average across all technology fields. Estimates for the 4CEEs are available upon request but they rely on a very small sample.

a. Martin and Verhoeven (2023): https://cep.lse.ac.uk/_NEW/PUBLICATIONS/abstract.asp?index=10290
b. Ibid.

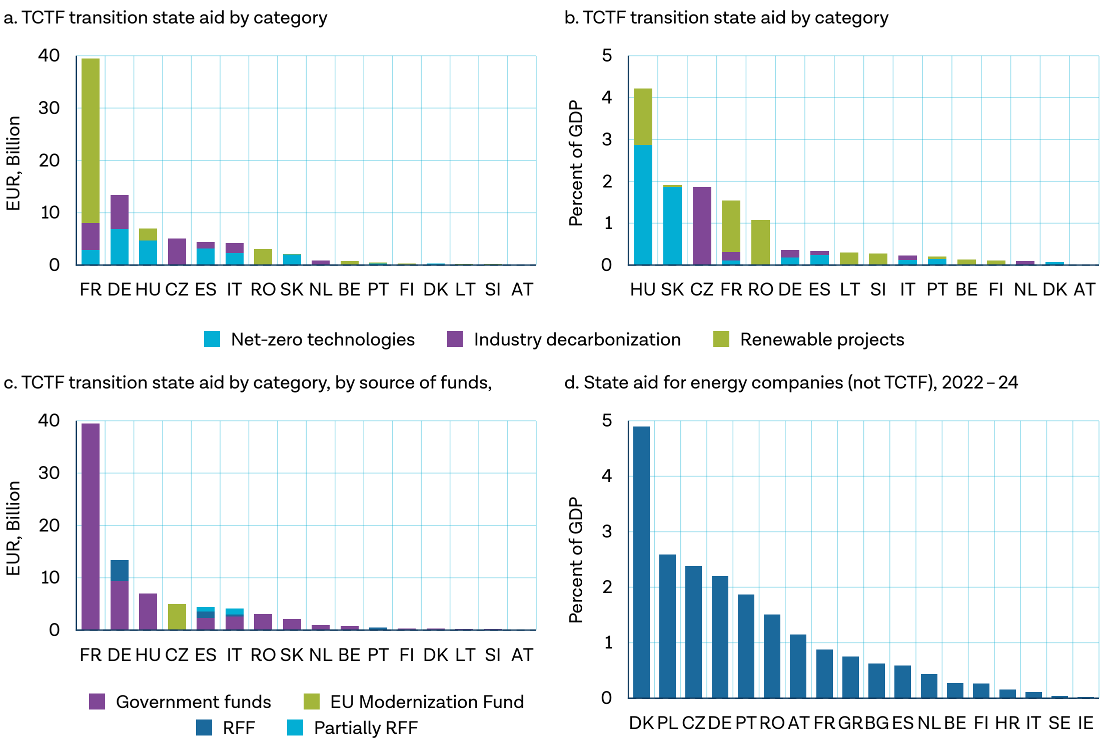
**So far, member states (and only one of the 4CEEs) have made heterogeneous use of the increased state aid allowance, channeling funding to renewable projects, industry decarbonization, and clean energy technologies.** Analysis of spending under the Temporary Crisis and Transition Framework (TCTF) based on data collected from the EU press releases (Figure 1.1, panels a – c)[15] shows that so far 16 member states have invoked the TCTF, but only a few have used it to subsidize clean energy technology manufacturing. While large Western European member states have committed most funds (panel a), three Central Eastern European member states have deployed most resources relative to their economies (percent of GDP) (panel Figure 1.1, panel b). Several other member states have instead complemented supply-side subsidies for manufacturing with demand-side subsidies for manufactured items (in industry or renewable projects).

15 This analysis is based on the data collected from the EU press releases.

**Most of the recently deployed state aid was funded with member state's own funds** (Figure 1.1 panel c). While the EU has relaxed the framework for state aid, the funding for the selected schemes is predominantly from own resources, with some use of the EU Recovery and Resilience Facility (RRF) (Figure 1.2 panel c).

**The 4CEEs so far have not made use of the more relaxed state-aid rules, instead prioritizing energy subsidies.** Among the 4CEEs, based on this analysis, only Romania has used funds under the TCTF, predominantly for renewable energy project deployment (similar to Belgium, Finland, Lithuania and Slovenia) (Figure 1.1 panels a – b). In addition, the 4CEEs have spent relatively more on subsidies for existing energy companies, which are mostly fossil fuel based (panel d). While these subsidies were critical to shield households and firms from the energy price shocks,[16] the data suggests that at the time of the analysis, the 4CEEs have not made use of the new EU framework's relaxation of state-aid rules for investments in clean energy technologies or industry decarbonization; with other contemporaneous policies (non-clean energy subsidies) effectively working in an opposing direction of the subsidies geared towards clean energy and energy efficiency.[17] This corroborates with the broader industrial policy trends in the 4CEEs, where industrial policy (more generally) is on rise but less so than the EU average; and with more reliance on subsidies, compared to other industrial policy tools (see Box 1.3). As state aid is not the only instrument for attracting industries, the broader policy — and incentive — space needs to be well understood before deploying additional incentives, especially given the fiscal constraints some of the 4CEEs are facing.

**FIGURE 1.1 Selected state-aid in the EU, 2022 – 2024**




*Source:* Data collected from EU press releases. Note: TCTF state aid started in March 2023. The support for energy companies started already in 2022 after Russian Federation's invasion of Ukraine and the subsequent disturbance of the energy markets. Countries not shown were no mentioned in the press releases.

16 See World Bank EU RER 9 Energizing Europe https://openknowledge.worldbank.org/items/05c34aa3-67f6-44d1-bb41-46b191ef73c3

17 See for instance, World Bank State and Trends of Carbon Pricing 2024 for discussion: https://openknowledge.worldbank.org/entities/publication/b0d66765-299c-4fb8-921f-61f6bb979087

## BOX 1.3 The rise of the industrial policy globally and in the 4CEEs, and its composition

**Industrial policy is on the rise globally, particularly in the higher-income countries, including the 4CEEs.**[a] Using a publicly available policy inventory (the Global Trade Alert (GTA) databaseb and natural language processing to classify trade policies into industrial policy at a high resolution (country-industry-year level) or otherwise (Table B1.3.1), Juhasz et al. (2022) show that the number of trade-related measures intended as industrial policy are increasing, especially since 2020, both globally, but particularly at the higher-income countries, including the EU (Figure B1.3.1).

**TABLE B1.3.1 Number of trade and industrial policies passed, 2008 – 2022**

| | Trade policies | of which industrial policy | Share of industrial policy (percent) |
|---|---|---|---|
| Bulgaria | 78 | 36 | 46.2 |
| Croatia | 106 | 46 | 43.4 |
| Poland | 433 | 255 | 58.9 |
| Romania | 134 | 70 | 52.2 |
| 4CEEs avg | 188 | 102 | 54.2 |
| ECA avg (excl. 4CEE) | 68 | 10 | 14.3 |
| USA | 8,513 | 4,862 | 57.1 |
| EU27 avg (excl. 4CEE) | 323 | 205 | 63.4 |
| OECD avg (excl. 4CEE) | 804 | 465 | 57.4 |

**Industrial policy measures are also on the rise in the 4CEEs, but less so than in the EU on average.** In the years 2008 to 2022, each of the 4CEEs passed a total of 188 trade policies on average, of which 102 were industrial policies on average, according to the data and approach of Juhasz et al. (2022) (Table B1.3.1). The average number of industrial policies in the 4CEEs present only a half of the EU average of 206 by country, and even further behind the OECD average (the latter driven in part by the very high number of interventions in the United States) (Table B1.3.1). Within the 4CEEs, the number of policies passed increased over the years, though unevenly, and with a clear pickup of measures in 2022, when some of the EU-wide legislation had started to be passed.

**FIGURE B1.3.1 The use of industrial policy is on the rise...**

Annual industrial policies passed globally

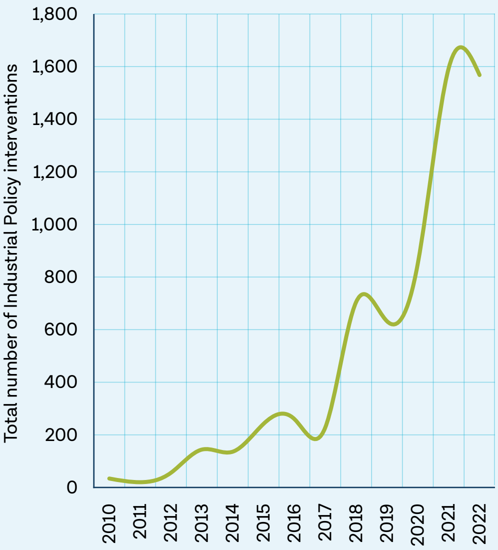
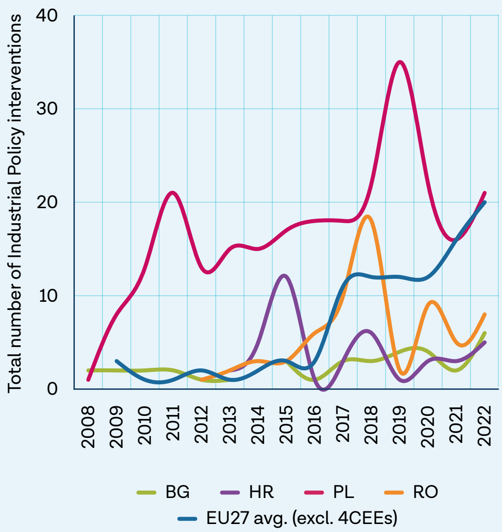


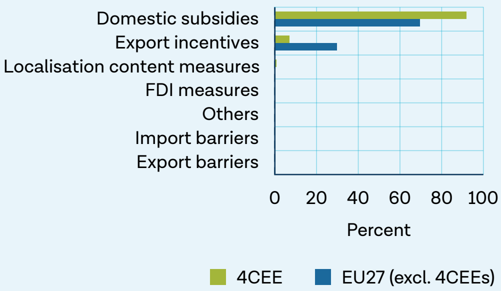

**FIGURE B1.3.2 ...including in the EU and the 4CEEs**

Annual industrial policies passed in each of the 4CEEs and the rest of EU average (simple)




**While the count of industrial policy measures passed may be lower in the 4CEEs, the types of instruments used are similar to those in rest of the EU, though more focused on domestic subsidies.** Out of the policies classified as industrial policies in the GTA between 2008 and 2022, in the 4CEEs 92 percent were in the form of domestic subsidies, with very little use of other instruments of industrial policy (Figure 1.B1.3.3). While domestic subsidies dominate the industrial policy toolkit in the EU and in other high-income countries,

**FIGURE B1.3.3 Types of industrial policy interventions — the 4CEEs and the rest of EU**




the dominance of subsidies is less pronounced in the rest of the EU (70 percent), with export incentives also prominently used (30 percent) (Figure 1.B1.3.2), leaving little room for other instruments. Among the 4CEEs, three forms of subsidies dominate the industrial policy space: state loans, loan guarantees, and financial grants (Figure B1.3.4).

**Going forward, the 4CEEs could benefit from relying more on measures strengthening the domestic environment.** Given the strong linkages with other countries, the spillovers of the domestic subsidies (that the 4CEEs have been relying on much more than the rest of the EU) could be low as — with the large reliance on foreign suppliers (see chapter 2) — they may leak abroad, especially in Bulgaria and Croatia (which also had the lowest share of state subsidies among the 4CEEs). Combining them with measures to strengthen the 'between' domestic environment could help capture more spillovers.

**FIGURE B1.3.4 Composition of the industrial policy tools used in the 4CEEs (2008–2022)**


*Source:* World Bank calculations using Juhasz et al. 2022.

a. Juhasz et al. (2022), (2024).
b. Evenett (2009).

**While setting the direction for the bloc overall, the EU policy leaves the policy and investment decisions — as well as financing — to the member states, amidst rising fiscal challenges, continued administrative constraints, and lack of coordination.** As highlighted above, the funding for the clean tech manufacturing investments in EU is predominantly from national resources, and with no effective coordinating mechanisms.[18] The 4CEEs — together with several other countries — are increasingly fiscally constrained, with high fiscal consolidation needs, raising the importance of treading any national industrial strategy or plan decisions in a well-informed manner, including the need for assessments of existing policies and their effectiveness.

**The EU policy left it open as to how the measures would be used and coordinated by its member states.** The legislation is not prescriptive on the specific location within the EU where this new manufacturing would be established, nor is it currently backed by funding,[19] leaving the critical policy decisions — and the corresponding funding — to each member state.

**Designing the policy response at the national level in the member states aiming to tap some of these opportunities requires understanding the layout and flow of existing value chains.** While it is tempting to deploy incentives to boost productive capabilities in clean tech manufacturing and their input value chains, the wider policy and capability ecosystem needs to be considered, as the incentives are likely to be disrupting competitive market forces in allocating other scarce resources. Understanding the layout and flow of existing value chains for clean tech manufacturing sectors and products, and the capabilities and constraints of domestic firms to participate in them is critical to identifying potential opportunities and formulating potential targeted policies that countries may consider.

**It is also important to be aware of the pitfalls of designing industrial policy poorly.** There are well-known challenges to designing industrial policy.[20] Much information and expertise are needed on the part of the government about which targets to set for what purpose and for which industries, if at all. The decision process can also be captured by special interests. Firms and sectors are likely to lobby governments to receive preferential treatment, and there need to be sunset clauses that define when and under what conditions (e.g. failure to achieve a target) the support will stop. Finally, scarce public resources deployed for incentives are fundamentally cutting spending elsewhere in the short run, so the opportunity costs must be kept in mind (see Box 1.2). These challenges are an additional motivation for gaining a better understanding of where the member countries stand *vis-à-vis* the sectors targeted by the EU and reduce the risk of the poor policy design.

### BOX 1.4 Trade matters for growth, raising living standards and job creation

**Trade is an important driver of growth, productivity and jobs; the 4CEEs are increasingly open to trade and integrated to the EU.** Globally, empirical studies estimated that a 1 percentage point of GDP increase in trade openness has increased per capita income by 0.2 percent.[a] The EU Single Market is estimated to have increased real income in the European Union by approximately 6.4 percent.[b] All 4CEEs are increasingly open to trade: their trade flows and trade integration with the rest of the world have increased rapidly between 2000 and 2022. Increase in trade flows of the 4CEEs have been driven by increases in trade with the EU, which is their main trading partner (Figure B1.4.1). The 4CEEs also import most of their goods from the rest of EU, receiving between 60 – 70 percent of their goods imports from other EU member states. Despite the rising importance of services in the economy, and contrary to the trend in the EU, it is goods trade in the 4CEEs

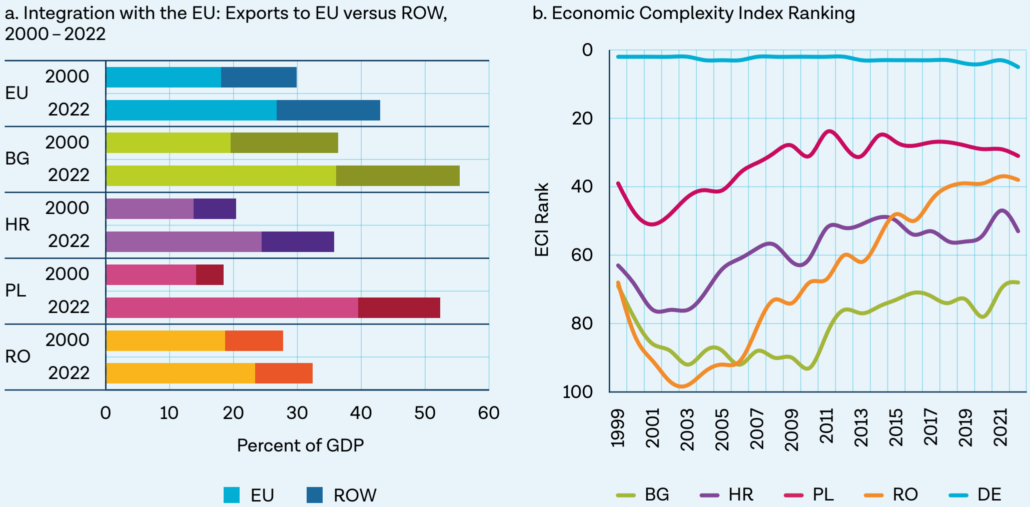
18 See the EU Future of Competitiveness report, 2024.

19 Ibid.

20 Criscuolo et al. (2022a).

that continues to dominate their exports, with services playing a relatively limited role. The 4CEEs exports have undergone considerable transformation of their exports reflecting their expansion into manufacturing products that require more technical know-how and sophistication, as in part reflected in their complexity ranking (Figure B1.4.1, panel b).

**FIGURE B1.4.1 The 4CEEs are increasingly open to trade, and increasingly integrated with the EU, and continue to increase their export sophistication**



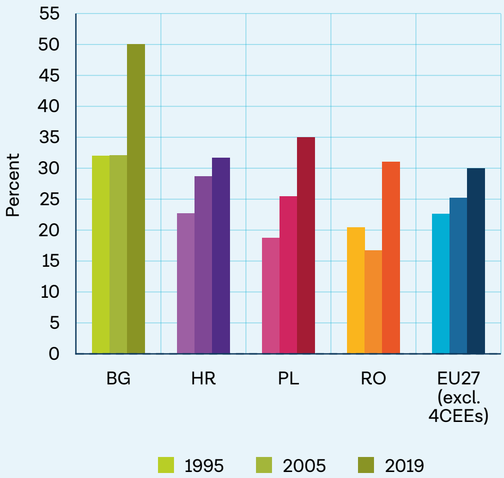

*Source:* a. Eurostat [ds-045409, nama_10_gdp]. Note: Goods trade reported on BPM5 basis. Decomposition of goods trade by partner on BPM6 basis not available. Decomposition of services trade by partner not available. b. Green Transition Navigator. https://green-transition-navigator.org/

*Note:* a. The Economic Complexity Index (ECI) ranks countries according to the similarity of the products they are competitive in. Countries with a high ECI have competitive strengths that are similar to other countries with a high ECI, and these tend to be advanced economies that are able to export technologically sophisticated products (Mealy and Teytelboym, 2022).

**Trade has played a key role for job creation, with an increasing share of workers depending on trade in the 4CEEs.** Export-related jobs have been a main driver for the 4CEEs to generate jobs in the past, including after the 2008 – 9 Great Recession, when other middle income countries' export-related jobs stagnated or declined (Winkler et al. 2024). Employment linked to exports has increased its share of total employment across the EU, but this increase was more pronounced in the 4CEEs (Figure B1.4.2). The measures of employment in exports account not only for the direct job contribution within the export sector, but also consider indirect links to domestic supplying sectors and their job contribution. For instance, car part exports create jobs not only directly in the automotive manufacturing sector, but also indirectly in the metals sectors if these are not imported, and in business services (ranging from research and development, design, transport and logistics, to marketing services). For the purpose of this report, these are referred to as direct and indirect jobs linked to exports and, unless stated otherwise, the sum of these is discussed. By 2019, the share of jobs sustained by production for export was higher in all 4CEEs than in the rest of the EU 27 on average, which stood at 30 percent weighted by population. In Poland, more than one in three jobs depend on exports, while in Bulgaria every second job is tied to exports, surpassed only by Luxembourg (61 percent) and Ireland (57 percent). Underlying the shift in shares (Figure B1.4.2) are divergent growth rates. In the 4CEEs, employment in jobs linked to domestic demand has not grown at all over 14 years or declined, with the mild exception of Poland growing domestic jobs at 0.05 percent per year. This compares with 0.3 percent compound annual growth at the EU level.

**The export-linked manufacturing jobs growth rate across the 4CEEs (except Croatia) was four or more times faster than in the rest of the EU.** As a result of this much higher growth rate in manufacturing jobs, they contributed as much (Bulgaria, Poland) or nearly as much (Romania) to export-related employment growth as business services. Business services make up a smaller share of export-related employment outside Croatia whereas agriculture played a more substantial role in Bulgaria and Romania. While over half of jobs in exports in the rest of the EU were linked to business services (54 percent), they account for a substantially smaller share at 41 percent or less in 3 out of 4 of the 4CEEs (Figure B1.4.3). In Poland manufacturing export jobs and jobs indirectly linked are the most important component, accounting for more than half of all export jobs. In Bulgaria and Romania, agriculture took between 20 percent and 33 percent, squeezing the manufacturing export share. Nevertheless, manufacturing was more important for export-related jobs than business services in all of Bulgaria, Poland and Romania, showing the importance of this sector for export-employment overall (Figure B1.4.3). Croatia has far higher share of jobs in business (67 percent) and other services (4 percent) than even the EU average at 67 percent, on account of its tourism industry.

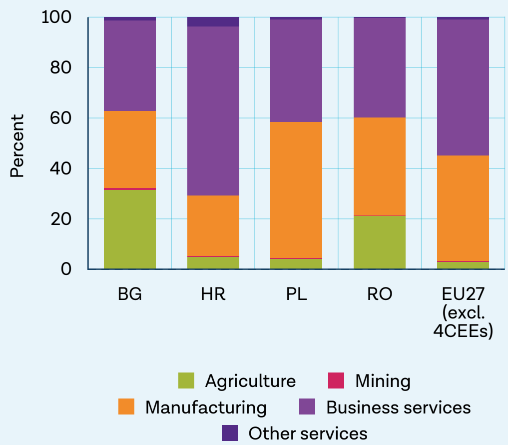
**FIGURE B1.4.2 Employment embodied in exports as share of total employment**




*Source:* WB staff computations following Winkler et al. (2023). Data: OECD Trade in Employment 2023 release.

**FIGURE B1.4.3 Sectoral growth and composition of export-related employment**

Shares of export employment in 2018

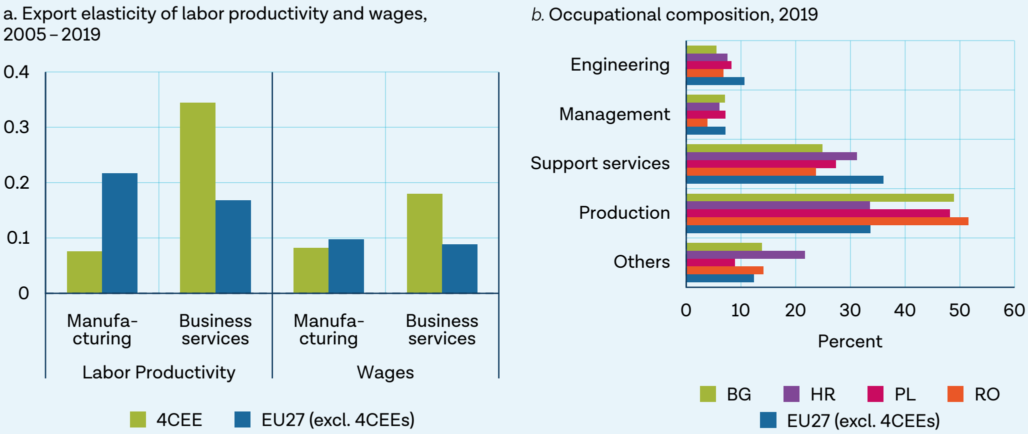



*Source:* WB staff computations following Winkler et al. (2023). Data: OECD Trade in Employment 2023 release.

**For every job in manufacturing for exports, more indirect jobs are created in the domestic supply chain than by any other sector, but the 4CEEs lag the EU 27.** Linkages to supplying sectors have been traditionally high for manufacturing exports globally, with 1.6 indirect jobs created for every manufacturing job in exports on average in a sample of 52 countries in 2018 (Winkler et al. 2024). These figures have been lower, around 1, in the rest of the EU and even lower in the 4CEEs, where every manufacturing export job created between half and 0.8 jobs in the domestic supply chain (Figure B1.4.4). The low multiple indicates a less developed domestic supply sector in the 4CEEs. Business services created between 0.45 and 0.6 indirect job in the 4CEEs in 2005, higher than the average elsewhere in the EU of 0.4, but converged to the EU average by 2019, with Romania still showing a higher multiple. Despite the relatively low manufacturing multiples in the 4CEEs, they still provide the largest job multiplier.

**Manufacturing employment growth is associated with lower labor productivity but the same wage growth as in the rest of the EU27.** For direct jobs only, the elasticity of labor productivity in manufacturing with respect to exports is 0.08, that is, a 10 percent increase in manufacturing exports was associated with a 0.8 percent increase in labor productivity (Figure B1.4.4, panel a). In the rest of the EU this elasticity was 0.2. For direct jobs in business services, the elasticities are in the opposite relation and higher: for 10 percent increase in business service exports labor productivity rose 3.4 percent on average in the 4CEEs. Part of the explanation of these different elasticities might be the different occupational structures associated to different activities within a sector in the 4CEEs from the rest of EU27 (shown for all sectors in Figure B1.4.4). Much larger shares of workers are in production jobs in the 4CEEs, whereas the EU employs a larger share as support services and engineers. As a result, wage growth was also slower, albeit only marginally, leading to further divergence in manufacturing for export wages from the existing large differential at the beginning of the period. For manufacturing exports to contribute more to competitiveness and income growth and perceived equally favorably as business services such as IT, the 4CEEs elasticities would need to be higher.

**FIGURE B1.4.4 Labor productivity and wage elasticities of only direct export employment by sector, and occupational composition of employment**




*Source:* WB staff computations following Winkler et al. (2023). Data: OECD Trade in Employment 2023 release.

*Note:* In the occupation groups, support services include other professionals (besides managers, engineers and health and education professionals, the latter two in the 'Others' group), clerical support workers, and sales workers. Production includes craft workers and machine operators, agricultural workers, and drivers.

**This analysis highlights the importance of how the EU efforts to boost green equipment value chains play out in the 4CEEs for their employment.** The EU's newfound focus on boosting domestic manufacturing in these industries presents an important opportunity for the 4CEEs labor markets. It holds the potential to create new demand for their manufacturing-dependent export job market, which has been among the most important drivers of overall employment creation in the past 20 years. Moreover, the new industries can act — just like other high value-added sectors — as a booster for productivity and wages growth. However, this would only happen if the 4CEEs manage to attract some of the investment in the growing sectors such as clean energy technologies. There is also a risk that some manufacturing export jobs will be lost, e.g. in the manufacturing of components for petrol or diesel cars that are not needed for electric vehicles.

a. Ohnsorge and Quaglietti (2023) https://documents1.worldbank.org/curated/en/099450203102326513/pdf/IDU0f731bf7c0ba660447f089fe0353b4723e925.pdf

b. https://www.europarl.europa.eu/RegData/etudes/IDAN/2019/631063/IPOL_IDA(2019)631063_EN.pdf

Chapter 2

# Leveraging trade and firm data to inform policy direction

**The analysis presented in this report leverages two concepts: economic complexity and value chains.** Economic complexity aims to capture the knowledge in an economy as expressed in the products it makes, calculated based on the diversity of a country's exports and their ubiquity.[21] First, higher economic complexity, proxied by a greater diversity goods with productive, specialized know-how, i.e. the country's ability to produce a great diversity of sophisticated products, is correlated with higher income levels (see Box 2.1 for details and caveats). Secondly, global trade patterns have shifted over time, with the fragmentation of production of goods (in its parts and components) across countries, with important connections across firms, contributing to productivity and income growth (please see Box 2.2 for details).[22]

**This report applies a sample of emerging or novel analytical tools anchored in trade and firm-level data for the 4CEEs to provide insights into their current participation and potential opportunities in the selected clean tech value chains.** Two of the tools — Green Value Chain Explorer (GVCE) and the onshoring simulations — leverage economic complexity and value chain analysis (see Box 2.1 and Box 2.2 for details, including pros and cons) to study in which technologies and parts of the value chains the 4CEEs already participate in, and where they show particular opportunities for expansion, taking into account export trends, revealed comparative advantage, and broader supply and demand factors. These two tools leverage fine-grained (HS6) trade data in innovative ways, though not without caveats (including relying on gross rather than *net* export values, and with less than perfectly precise product mapping — see Box 2.2). Section 2.4 turns to an international cross-border firm-level dataset (FactSet) to study the value-chain networks the selected 4CEEs clean tech manufacturers operate in. The aim is to gain insights into whether they have a strong international network and whether they rely on domestic industries, as that, too, can help policymakers in assessing integration in clean tech value chains, and instrument selection. Finally, leverages the selected interviews with cross-border investors in clean tech manufacturing and/or deployment to understand the key factors driving their investment decisions across the EU and neighboring markets, and comparing these factors across the 4CEEs. This analysis is not exhaustive, with much more country (and regional)-level analytics required to adequately inform the policies that shape future export, growth and job trajectories — but aims to showcase a sample of innovative approaches to existing and emerging data and methodologies.

### BOX 2.1 Emerging complexity toolkit may help answer some questions about industrial strategy design

**Increasing economic complexity and the rise of global or regional value chains add dimensions to the challenge of selecting products or industries to be supported.** Over the past two decades, the economic complexity scholarship has increased the production of data, digital platforms, and analytical methodologies that can aid industrial strategy design. It is important to understand the methods and caveats involved in generating the results and policy prescriptions, in order to use them for industrial targeting and industrial strategy more broadly.[a]

**Economic complexity approaches can help guide a country's selectivity when considering an industrial strategy in the following aspects:**

1. They can provide proxy measurements about the current level of complexity of economies and the sophistication of products.

21 https://atlas.cid.harvard.edu/

22 World Bank WDR 2020. https://www.worldbank.org/en/publication/wdr2020

2. They can provide insights into how related two products are to each other (called proximity), by calculating how many countries that export one product also export the other. By looking at all of these bilateral (i.e. between two products) proximities, they can map a network of products connected by proximities, the so-called product space. The product space can be drawn as a network graph. Products proximate to many others are in the center, and others that are less connected are on the margins of the graph.

3. By identifying which products in the product space a given country already exports, the product space allows to identify how proximate a country's exports are to product that the country does not yet export, the so-called density around such a potential export. Previous research has found that historically, countries have more often started new export lines when their existing exports were dense around it (path-dependency), although some countries have instead charted path-defying export diversification.[b]

4. They can help visualize and think through the potential trade-offs between the proximity of a new product and its sophistication, or contribution to increasing a country's economic complexity and growth potential. As Hidalgo 2023 points out, this is particularly important for designing "diversified portfolios" of targeted industrial sectors that combine both ambitious and more easily accessible sectors.

**The economic complexity approaches come with methodological and interpretation caveats:**[c]

1. Trade data does not always reflect the "productive capabilities" of a country, not least because of today's global hyper-fragmentation of production (just because a country exports a given product does not mean it produces the whole product). Put differently, due to data availability, the analysis often relies on gross rather than net export data. As a result, the more imported inputs are embedded into a product, the less its export is a good proxy. The more inputs are domestic, the more adequate is the measure. Furthermore, data on the relatedness of products is probabilistic and does not necessarily capture the concrete relationships between physical (and non-physical) components and processes involved in creating a product.

2. Even 6-digit trade codes[d] are often not nuanced enough to allow understanding whether the products in a given category correspond to the products used for a particular purpose in a particular productive activity, (the 'dual use' problem). This highlights the importance of more qualitative approaches (e.g. interviews with producers and engineers) to understand how countries may be able to participate in globally fragmented production systems, which the analysis presented in this report followed.

3. It can be tempting to misinterpret descriptive relatedness and proximity data as prescriptive information (e.g. "countries should only target products that are close by in the product space"). In fact, targeting related products requires the additional assumption that it is easier/advantageous to do so, and which is neither analyzed nor confirmed by the complexity analysis.[e] As Hidalgo (2023) stresses in his analysis of the policy implications of economic complexity methodologies, an equally sound take-away is that targeting sophisticated products may improve an economy's complexity and strengthen the foundation for sustained growth.

4. Finally, economic complexity and product space methodologies have to be combined with multi-criteria analysis that contemplates economic, productive, technological, political, and social parameters not captured by these methodologies.

**This report leverages some of these approaches to provide new insights.** It leverages trade data, with novel value chain mapping in collaboration with economists and engineers to study export opportunities, maps existing GVC networks for the 4CEEs; and goes one step deeper through interviews with investors in 4CEEs.

a. Hidalgo (2023) and Estevez (2024).

b. Hidalgo et al. (2007) https://www.science.org/doi/10.1126/science.1144581 ; Coniglio et al. (2021) https://www.sciencedirect.com/science/article/pii/S0022199621001021

c. See Estevez 2017 for a detailed analysis of the limits of product space methodologies as tools for industrial targeting.

d. Note: Publicly available tools, such as the Atlas of Economic Complexity and the Observatory of Economic Complexity are not consistent in the level of specificity of HS trade codes. Some include product categories at the 4-digit level of HS nomenclature (e.g. for Bulgaria); others are specified at the 6-digit level (e.g. for Poland).

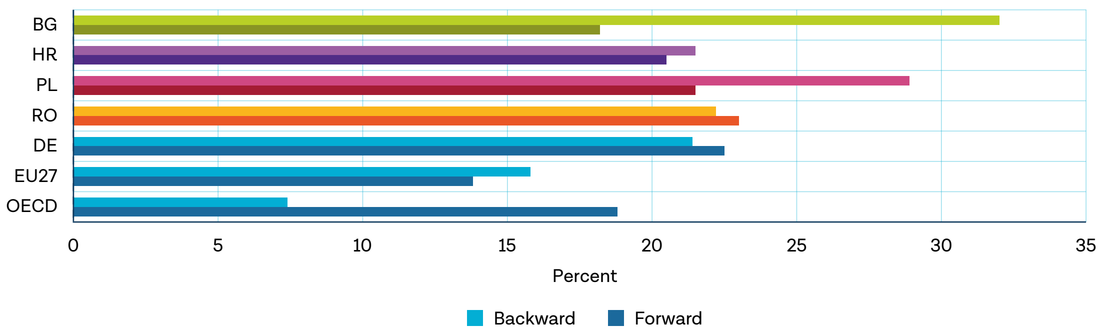
e. E.g. Coniglio et al. (2021).

**The five selected clean tech value chains are a subset of NZIA strategic technologies, and are technologically complex but mass manufactured.** This stands in contrast with custom-made technologies used in individual large projects (like nuclear or CCS technologies), and all of which fall under the broad set of technologies covered by the NZIA. This report zooms in on: solar PV, wind energy, electric vehicles (with focus on batteries), heat pumps, and electrolyzers. The selection is also closely aligned with the analytical focus of the recent *The Future of European Competitiveness report* (widely cited as the Draghi report).[23] All five technologies entail complex manufactured goods with multiple components, underpinned by international (global or regional) value chains. This report leverages the three value chains mapped out by Mealy and Rosenow (2024) (Solar PV, Wind, and EV), and contributes by mapping out electrolyzers and heat pumps; see Box 2.2 for technical details.

**The 4CEEs are well integrated into overall global value chains (GVCs) relative to the other EU member states** (Figure 2.1). Backward integration indicates the use of imported inputs for the production of exports (e.g. importing car parts to assemble cars for export). Bulgaria and Poland have the highest backward integration with GVCs, at 33 percent and 29 percent of GDP, respectively (Figure 2.1). Forward integration indicates that a country exports inputs which trade partners use to add value. Romania and Poland have the highest forward integration with GVCs at 24 percent and 22 percent of GDP, respectively. Romania has forward/backward integration levels comparable to those of Germany, and all 4CEEs have forward/backward integration levels that exceed EU and OECD averages.

**FIGURE 2.1 The 4CEEs are highly integrated in the Global Value Chains**

Forward and Backward Participation in Global Value Chains, 2020, (in percent of country's gross exports)




*Source:* OECD TiVA Database.

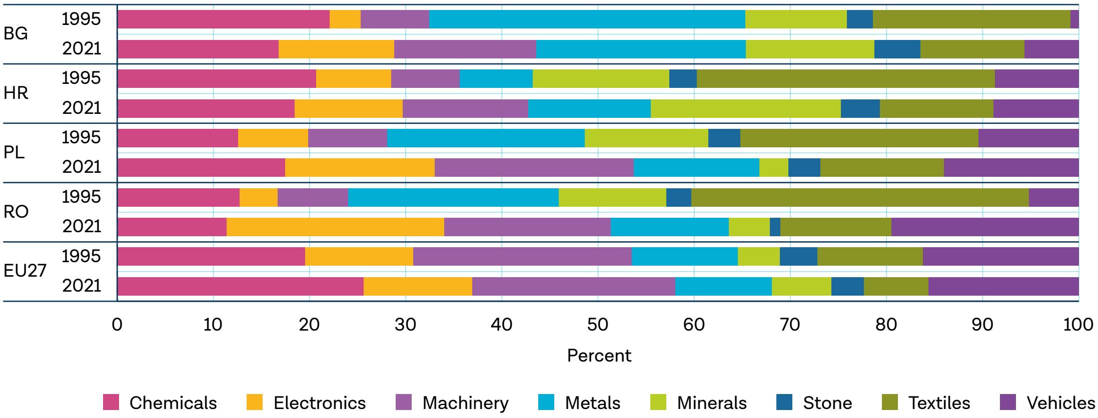
*Note:* Metadata definitions (OECD): Forward participation in GVCs: Domestic value added in foreign exports as a share of gross exports, by foreign exporting country, FEXDVApSH (c,p), represents the domestic value added from country c embodied in the gross exports of foreign country p, as a percentage of country c's total gross exports, EXGR (c). Backward participation in GVCs: Foreign value added share of gross exports, by value added origin country, DEXFVApSH (c,p), represents the foreign value added from "partner" country p embodied in the gross exports of country c, as a percentage of country c's total gross exports, EXGR (c).

**Industrial exports in the 4CEEs have undergone considerable changes to their composition, reflecting their expansion into manufacturing products that require more technical know-how and sophistication** (Figure 2.2). While the composition of industrial exports in EU27 has remained relatively constant between 1995 and 2021, Romania's exports of vehicles, electronics, and machinery increased from 16 to 60 percent of industrial exports and its textile exports shrank from 35 percent to 12 percent of exports. Bulgaria, Croatia, and Poland moved away from textile exports, which declined considerably over the same period. In all but Croatia, exports of metals, minerals, and stone also saw a decline in their shares.

23 Part A: The future of European competitiveness — A competitiveness strategy for Europe; Part B: The future of European competitiveness — In-depth analysis and recommendations. The selected clean technology sectors in the report: solar PV, wind, batteries, heat pumps, CCUS, and electrolyzers, are assessed as "the most critical and promising technologies where the EU has a comparatively large market share and deployment potential".

**FIGURE 2.2** **4CEEs goods exports are expanding in sectors requiring more know-how and sophistication**

Industrial Exports by Product Category, 1995-2021 (in percent of industrial exports)



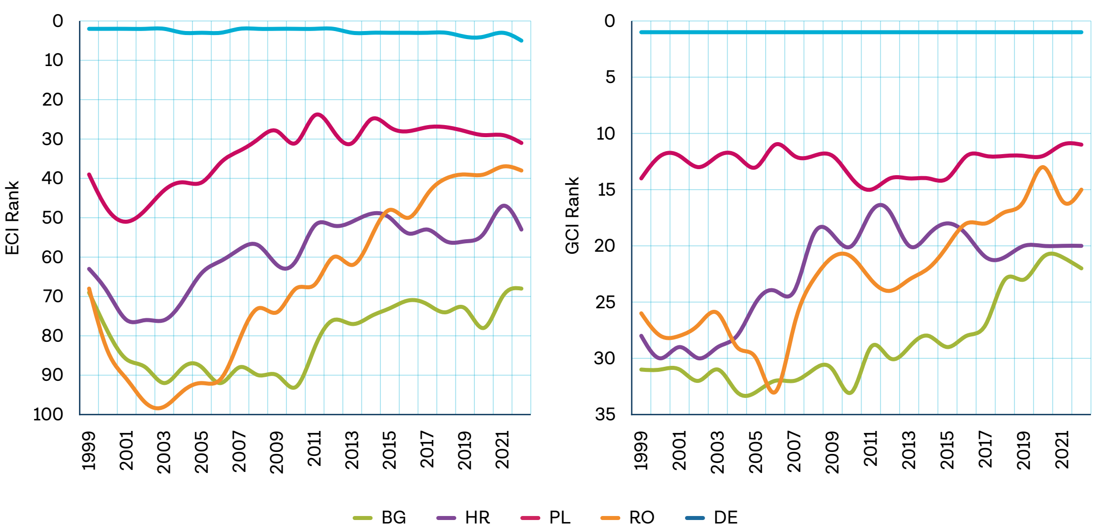

*Source:* Harvard Atlas of Complexity.

**This shift to more sophisticated industrial production overall is also reflected in the 4CEEs economic complexity index, including those products associated with environmental benefits (green complexity)** (Figure 2.3). Poland ranks the highest in its relative economic complexity and ability to export technically sophisticated products competitively while Bulgaria ranks lowest (Figure 2.3, panel a). Romania's relative economic complexity improved markedly in between 1999 and 2018. In recent years, relative economic complexity has remained fairly leveled in Croatia, Bulgaria and Poland.

**FIGURE 2.3** **The 4CEEs have showcased increased ability to competitively export more technologically sophisticated products, including in green technology manufacturing**

a. Economic Complexity Index Ranking

b. Green Complexity Index Ranking




*Source:* Green Transition Navigator. https://green-transition-navigator.org/[ADD

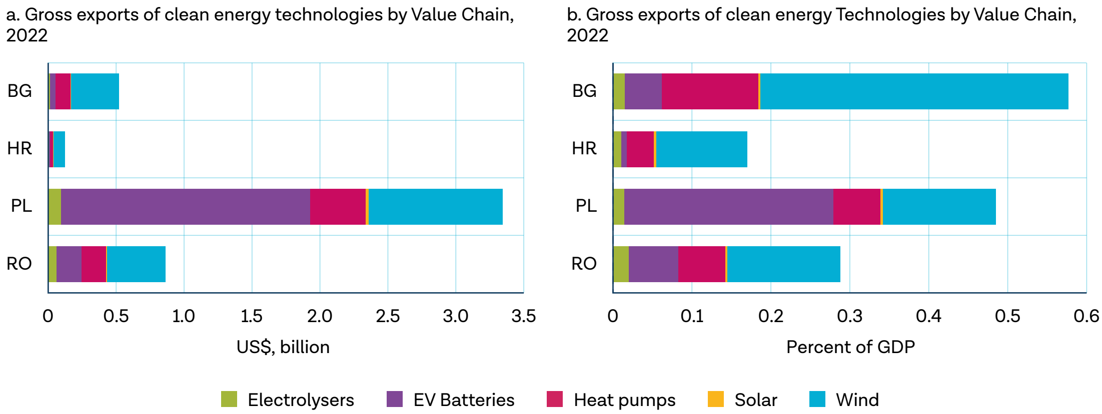
*Note:* a. The Economic Complexity Index (ECI) ranks countries according to the similarity of the products they are competitive in. Countries with a high ECI have competitive strengths that are similar to other countries with a high ECI, and these tend to be advanced economies that are able to export technologically sophisticated products. Mealy and Teytelboym (2022)
b. The Green Complexity Index (GCI) ranks countries by their ability to competitively export green technologically sophisticated products. The GCI measures countries' green competitiveness based on the number and Product Complexity Index (PCI) of the green products they are competitive in. (Andres, P. and Mealy, P. (2023) Green Transition Navigator. Retrieved from www.green-transition-navigator.org)

**In terms of cultivating competitive capabilities in green products, among which is clean tech manufacturing, Romania and Bulgaria have made considerable advancements in the rankings over the last two decades** (Figure 2.3. panel b). However, Croatia is slipping in its relative Green Complexity Ranking, potentially signaling fewer capabilities in producing green products and technologies with environmental benefits compared to other countries. Poland has the highest relative ranking of green complexity, albeit one that has remained somewhat stagnant over recent decades. The rest of this section provides more fine-grained analysis for the five selected clean tech value chains.

## The 4CEEs already participate in the clean tech value chains

**The 4CEEs participate in clean energy tech value chains, to a varying degree and across different segments.** Annual exports of goods and subcomponents across solar, wind, EV batteries, heat pumps, and electrolyzers are estimated to range between US$122 million in Croatia to over US$ 3 billion in Poland (Figure 2.4, panel a).[24] As a share of GDP, they range from 0.2 percent in Croatia, to 0.6 percent in Bulgaria (Figure 2.4, panel b).

**FIGURE 2.4 The 4CEEs already export goods in green value chains, primarily subcomponents (rather than end products), of varying complexity**




*Source:* WB staff calculations.

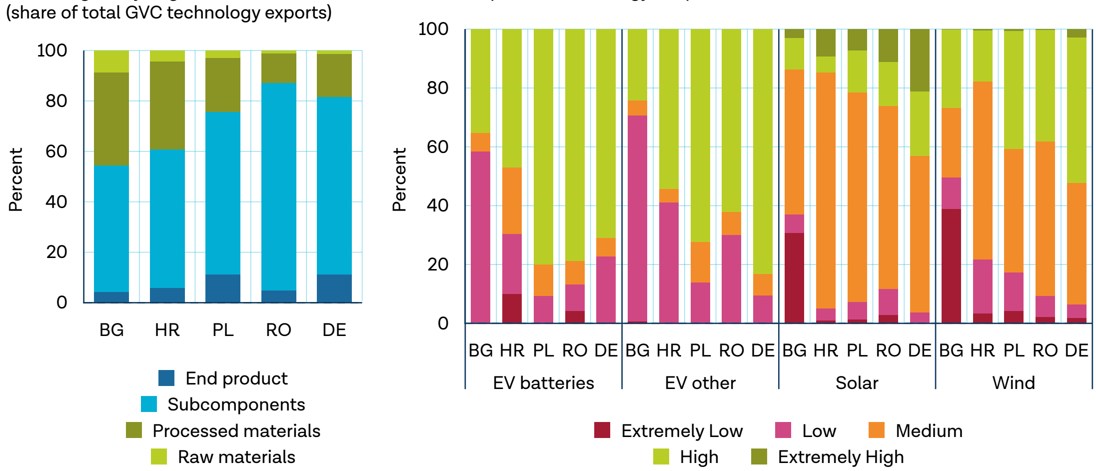
**The 4CEEs focus on subcomponents and products of medium complexity, pointing to growing sophistication and a mid-tier positioning in these value chains** (Figure 2.5). The 4 CEEs predominantly export subcomponents rather than final goods, with Bulgaria and Croatia also exporting a larger proportion of processed materials in their clean tech value chain exports (see Box 2.2 for details on methodology) signaling lower level of sophistication of their manufacturing (Figure 2.5, panel a). While goods manufactured in Poland and Romania, particularly in the EV value chain, show a higher degree of complexity, clean energy technology exports by Bulgaria and Croatia tend to be of low or medium complexity, again pointing to a relative lack of sophistication in their manufacturing (Figure 2.5, panel b).

24 Given the caveats explained in Box 2.1, the numbers reported here have been adjusted for dual-use products and technologies, which is crucial to avoid overestimation in our calculations. The export volumes are downsized so that the total value matches an imputed value, calculated using the European Commission's aggregate manufacturing capacity and equipment cost estimates, and therefore are lower (more conservative) than may be reported elsewhere.

**FIGURE 2.5 Annual Exports of selected clean technologies, by segment of value chain and complexity**

a. Annual Exports of selected clean technologies, by Segment of Value Chain (share of total GVC technology exports)

b. Exports of Clean Value Chain Technologies by Product Complexity Index (PCI), (share of respective technology's exports)




*Source:* Green Value Chain Explorer (WB internal) and WB calculations.

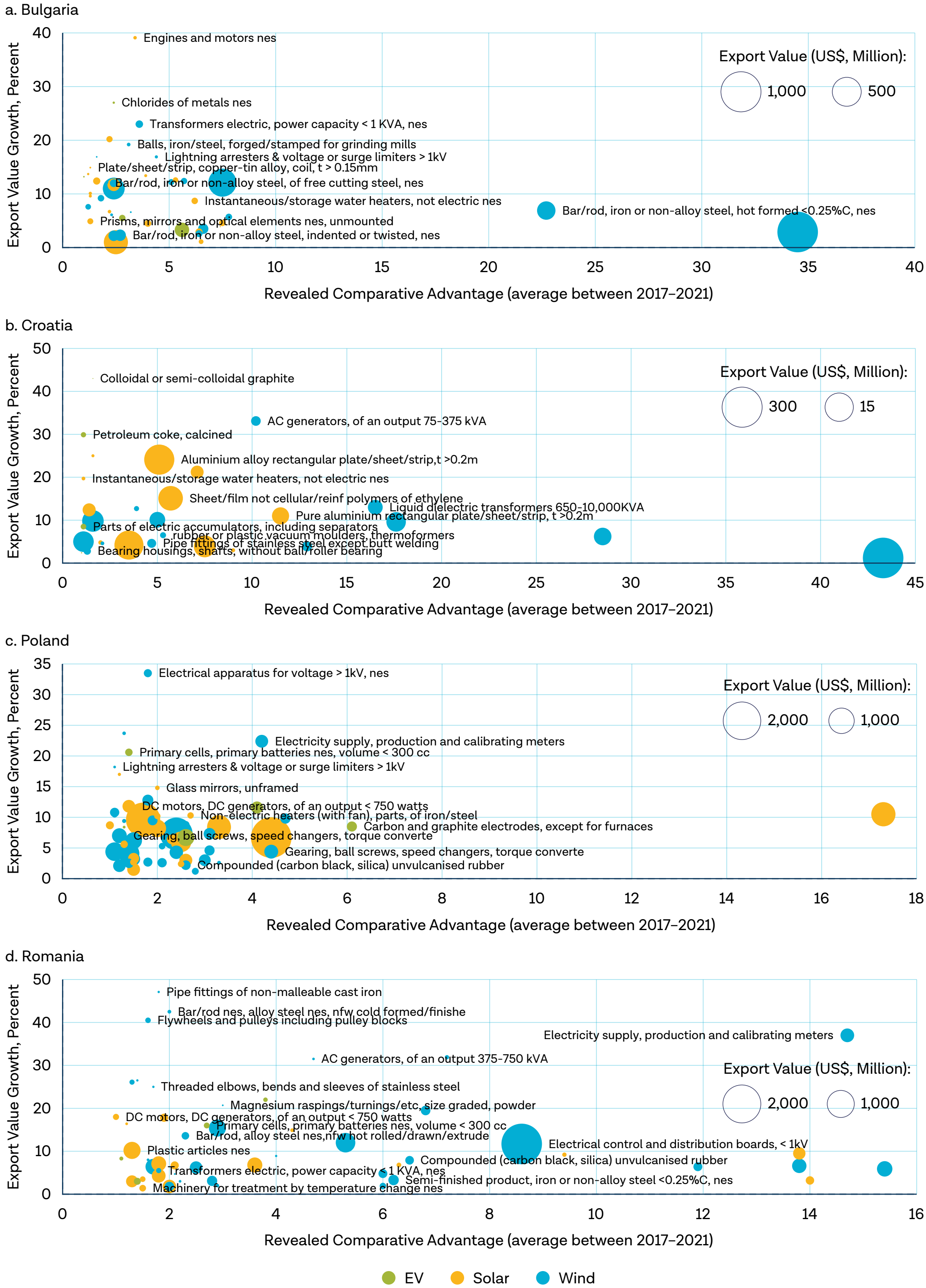
*Note:* for panels a and b, the results are shown for three out of five clean tech manufacturing exports: EV, solar PV, and wind, in line with the current functionality of the GVCE tool. b. Extremely Low=-3<PCI<-1, Low=-1<PCI<1, Medium=1<PCI<3, High=3<PCI<5, Extremely High=5<PCI<7.

**The 4CEEs showcase considerable export competitiveness and robust export growth rates in some of the selected value chains, signaling potential to capitalize on the transition to the green economy** (Figure 2.6). While specific products and value chains vary across countries, most 4CEE exports in net-zero technology manufacturing value chains showcase substantive growth rates. All four countries export multiple products, raw and processed materials, and subcomponents in solar, wind, and EV batteries. First, the 4CEEs exhibit export competitiveness — as measured by their revealed comparative advantage (see Box 2.2 for technical details) — in various technologically sophisticated components of the wind, solar, and to a lesser extent, EV battery value chains (Figure 2.6 a – d) This implies that firms in the 4CEEs have acquired specialized capabilities, and can build on them to progress to new, differentiated products with higher margins and fewer competitors. Second, the 4CEEs' best-established products in the wind and solar industries benefit from favorable market dynamics, as evidenced by strong EU import demand and high export growth rates. For instance, most of Romania's wind products have gained market share relative to those produced in other countries over the last five years.[25] Furthermore, multiple products that the 4CEEs export are close to the technological frontier — which bodes well in view of future market developments. The next section builds on this analysis to simulate the potential mix of clean tech products the 4CEEs may export in the next 5 – 10 years.

**However, the diversity of manufactured products and stages of production in the 4CEEs chains highlights the difficulty of devising targeted industrial policies.** This analysis highlights how complex and fragmented the production of the clean energy technologies is, and raises questions about, among other factors, the granularity of production to potentially target the policy support. Secondly, even the most fine-grained trade data and meticulous, highly-resource and skill-intensive mapping yields indicative but imprecise information as to whether a certain subcomponent of a good is used for a clean tech good, or goes into the production of a different final product.

25 See Romania Country Climate and Development Report 2023.

**FIGURE 2.6 Clean tech-related products with achieved export competitiveness (RCA ≥1) by country**




*Source:* Green Value Chain Explorer

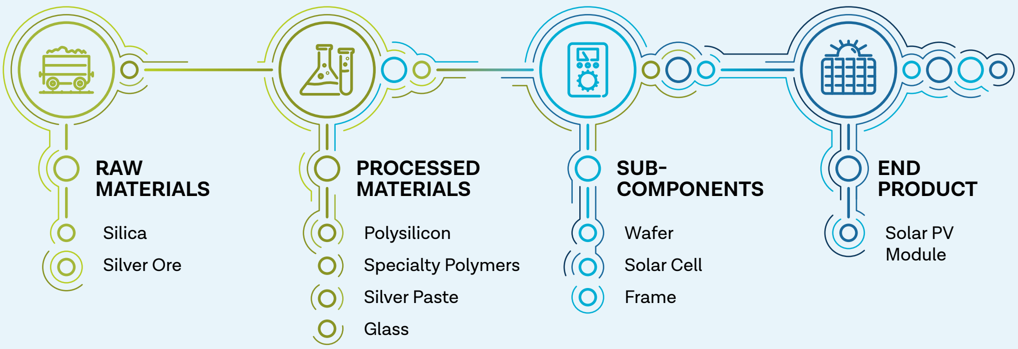
*Notes:* EV results shown for EV battery only (excluding other EV components); growth rates truncated at 50 to exclude minor outliers showcasing high growth rates from a small base.

## BOX 2.2 Using trade data to analyze export opportunities in clean tech value chains

**The Green Value Chain Explorer (GVCE) enables the exploration of countries' competitive strengths and potential opportunities around products associated with the solar (PV), wind (turbines) and EV value chains.** Production of these technologies is highly concentrated geographically. This novel tool has been developed by the World Bank Group.[a] The methodology can be summarized as follows:

- To analyze current trade patterns in the global value chains for solar PV, wind turbines and electric vehicles,[b] the authors collated a new dataset of end products, subcomponents, processed and raw materials classified under the 6-digit Harmonized System (HS) (Figure B2.2.1). The 6-digit HS is a standardized classification of traded products used by customs authorities around the world.
- The HS is the most fine-grained product classification that is comparable across all countries and over time. Figure B2.2.1 shows an illustration of the solar PV value chain, with sample products listed.
- Due to the challenges of classifying such products under the 6-digit HS,[c] the dataset is not exhaustive but intended to focus on the key identifiable elements of each value chain. All products included in the dataset were subject to independent evaluations by selected industry specialists.[d]

### FIGURE B2.2.1 Mapping the solar value chain




*Source:* Mealy and Rosenow (2024).

**The analysis identifies a list of products/components/subsectors as either existing strengths or potential opportunities for each country using Revealed Comparative Advantage and Product Complexity.**

- **Strengths:** To measure whether a country has export competitiveness in a clean tech value chain product, the GVCE draws on the Revealed Comparative Advantage (RCA), which captures the share of a given product in the country's total exports, divided by the share of the same product in world's exports. If RCA>1, the country is assumed to be competitive in the product, as it exports more than its 'fair share'.
- **Opportunities:** Opportunities are HS 6-digit products which the country of interest exports, yet without export competitiveness (RCA<1).

a. See Mealy and Rosenow (2024).

b. For EVs, authors construct two different sets of relevant value chain products: one more broadly defined and one more narrowly defined. The broader set includes HS products associated with the wider vehicle manufacturing value chain, e.g., products used in either internal combustion engine (ICE) vehicles or EVs. The narrower EV value chain only considers products that relate specifically to EVs, e.g., battery end products and components and the assembled EV end product.

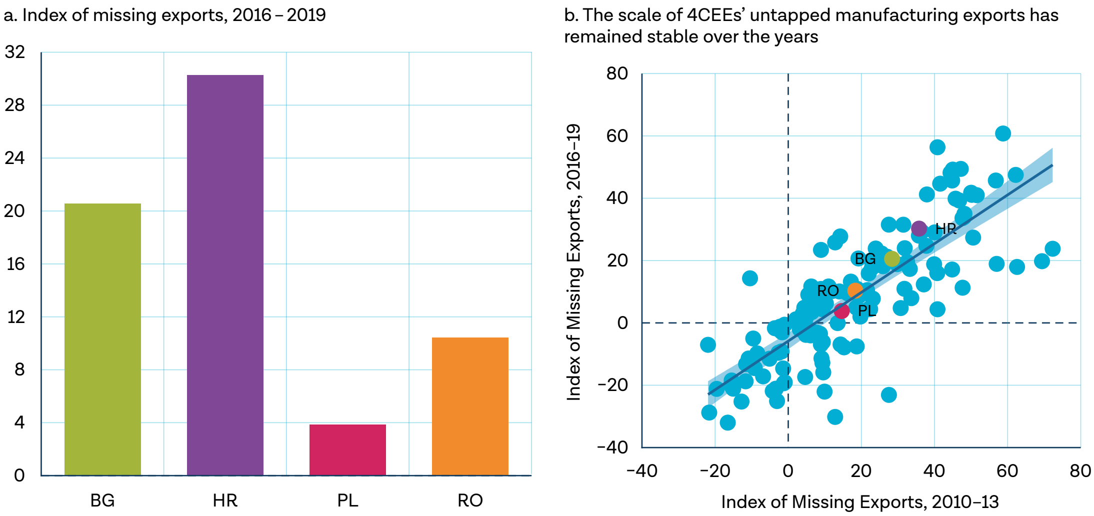
c. IISD (2020).

d. Many HS product codes are 'dual use' meaning that while they relate to products used by decarbonization technologies, they are also often used for many other different applications. As it is currently not possible to determine what proportion of trade in each product relates primarily to decarbonization technology usage, the total product export volumes in the results should be considered as an upper bound.

# The 4CEEs show untapped potential for export growth

**The 4CEEs have the potential to substantially increase their overall manufacturing exports.**[26] The trade gravity model can be used to assess how much trade we expect between any two countries based on their observable characteristics (distance between them, economic structures, and policies). Estimates of export potential derived by comparing actual export flows with those predicted through a gravity model[27] show that overall manufacturing exports from all 4CEEs fall short of what would be expected based on country characteristics (Figure 2.7, panel a), a gap that remains relatively constant over time (Figure 2.7, panel b). For instance, based on its observable characteristics, in 2016–2019 Romania had the potential to export 23 percent more of its manufactured goods. Similarly, model estimates indicate that Croatia could have increased its manufacturing export by 87 percent, and Bulgaria by 52 percent. These calculations are based on historical demand from the importers and do not capture a potential future demand increase in certain, e.g. clean tech, sectors. Poland's manufacturing exports were closer to their estimated potential during the period, only undershooting it by 8 percent. Sectoral results indicate that Romania has considerable potential in motor vehicles, electronics, and other manufacturing sectors — which encompass clean tech products such as EVs — signaling opportunities in clean tech value chains. Bulgaria, Croatia, and Poland also have potential in such sectors, to a varying degree. The 4CEEs' manufacturing exports notably underperformed (relative to model predictions) in markets outside the EU27, including North America and East Asia-Pacific — although this cross-country, high-level model does not capture important factors at the country-level or buyer-supplier relationships.

**FIGURE 2.7 Model estimates point to a moderate gap between potential and actual manufacturing exports in the 4CEEs, which has been relatively stable over time**




*Source:* World Bank calculations, adapted from Mulabdic and Yasar (2021).

*Note:* The index of missing exports ranges between -100 and 100. The maximum value of the index is obtained when observed flows are equal to 0, but the model predicts positive flows. In contrast, the minimum value (i.e., -100) is obtained when the predicted value equals 0 but positive flows are observed.

26 Please note that the gravity model results presented in this section are at the higher (not HS6) level on overall (not only green tech) trade flows.

27 Adapted from Mulabdic and Yasar (2021).

## Sizing the opportunities: a scenario analysis of export expansion in clean tech value chains

**The targets for internal EU production set out in the NZIA, if achieved, offer the 4CEEs an opportunity to expand exports to the EU27 and onshore a share of the production of net-zero technologies.** The EU market for the NZIA's net-zero technologies (called clean tech in this report) is projected to expand to meet the EU's Fit for 55 decarbonization targets. European Commission (2023)[28] modeling forecasts that by 2030, EU-wide deployment of five mass-manufactured technologies — wind, solar PV, batteries, heat pumps, and electrolyzers — will have grown by between 1.1 times (for electrolyzers) and 4.4 times (for batteries) (Table 2.1). This trend points to an important growth market for EU-based manufacturers who have shares of up to 85 percent of the domestic market today. The NZIA further envisages to growth EU market shares in EU deployment, implying even higher growth rates for EU-based manufacturers thanks to onshoring part of the production currently supplied by the rest of the world. This section presents onshoring scenarios for the 4CEEs.

**The European Commission estimates that if NZIA targets and EU decarbonization targets were to be met, as of 2030 the manufacturing capacity of European suppliers of five clean energy technologies will have grown by between 2.2 and 23 times** (see Table 2.1). In its projections, the European Commission assumes 2030 market shares for EU-made products higher than the NZIA's 40 percent benchmark, due to the effects of other complementary targets. For instance, the REPOWEREU plan sets a target of 10 million tons of annual domestic hydrogen production using domestically produced electrolyzers, which implies that 100 percent of EU-deployed electrolyzers would need to be manufactured in the EU.[29] The Commission also reports an NZIA+ scenario, where all domestic deployment is domestically supplied.

**TABLE 2.1** 2030 scenarios for EU clean tech deployment and EU-made equipment

| | EU deployment (GW/yr or GWh/yr for batteries) | | | EU share in EU deployment (in percent) | | | EU manufacturing capacity (multiple of 2022 capacity) | |
|---|---|---|---|---|---|---|---|---|
| Net-zero technology | 2022 | 2030 target | 2030 multiple of 2022 | 2022 | NZIA scenario | NZIA+ scenario | NZIA scenario | NZIA+ scenario |
| Wind | 15 | 42 | 2.7 | 85 | 85 | 100 | 2.7 | 3.3 |
| Solar | 33 | 53 | 1.4 | 3 | 45 | 100 | 23 | 52 |
| Battery | 23 | 51 | 4.4 | 54 | 90 | 100 | 7.3 | 8.1 |
| Heat pump | 139 | 610 | 2.2 | 60 | 60 | 100 | 2.2 | 3.64 |
| Electrolyzer | 23 | 25 | 1.1 | 10 | 100 | 100 | 10.6 | 10.6 |

*Note:* Figures and scenario assumptions from European Commission (2023). Investment needs assessment and funding availabilities to strengthen EU's Net-Zero technology manufacturing capacity.

**This section presents scenarios about product segments within the five clean tech value chains considered that the 4CEEs could potentially onshore, given the EU market's projected growth.** The scenarios take EU demand and domestic market share growth projected by the European Commission as given; furthermore, they assume that the 4CEEs as a group maintain their current joint share of EU production in these five technologies. It then analyzes where within the value chain the 4CEEs may have onshoring advantages. It is important to note that a scenario is not a prediction, but rather a "what if" analysis:

28 European Commission (2023).

29 Ibid.

it draws up a plausible expectation of export composition and volumes across 4CEEs, assuming that one of the European Commission's scenarios of EU market growth and domestic production were to be realized. This exercise serves as an illustration of what strengths the 4CEEs currently have (based on trade data and other sources) and could leverage in the new EU policy landscape.

**The scenario analysis relies on detailed mapping of the five value chains into trade categories, while identifying the subset of trade categories in which the 4CEEs have the potential to expand their exports.** In addition to solar PV, wind and electric batteries (Mealy and Rosenow, 2024)[30], two value chains were mapped to HS-6 product categories specifically for this analysis: heat pumps and electrolyzers (Box 2.3). For each HS-6 category, the simulation relies on calculating an onshoring attractiveness score that depends on supply, demand and market access factors that are country- and HS code-specific. The method is summarized in Box 2.3.

### BOX 2.3 Simulating an increase in export potential: value chain construction and method for onshoring analysis

The mapping of value chains to trade data was based on a detailed understanding of the underlying production process. For this report, two new value chains[a] were mapped to the harmonized system (HS) used to describe commodities and classify exports and imports. The mapping begins with a review of engineering literature that supplies a list of materials and components that go into the product. The second step consists of selecting an HS-6 code for each raw and processed material and subcomponent, and categorizing it based on where in the value chain this production step occurs. A subject-matter expert would carry out this task, which was then reviewed by engineers and a custom official to ensure the quality of the mapping from both the engineering and HS sides.

Assessing the onshoring potential of the 4CEEs in clean energy technologies relies on assessing their export potential for each HS code that is part of a relevant value chain.[b] The method combines three elements: (1) an estimate of the existing production level for each 4CEE by value chain step, as represented by one HS code, (2) the EU's projected increase in demand and domestic production share for each value chain by 2030, and (3) a score for each 4CEE country and production step (i.e., HS-code) indicating how attractive the 4CEE country is for onshoring that particular production step and exporting it to other EU member states. These elements are multiplied to obtain a dollar value of exports by HS code and destination market for each 4CEE as of 2030:

$$\text{2030 Exports per value chain}_{\text{by HS code}}\ [\text{EUR}] = \text{Multiple of EU 2022 demand}_{\text{by value chain and scenario}}\ [\text{a scalar}] \times \text{Onshoring attractiveness score}_{\text{by HS code}}\ [\text{a scalar}] \times \text{Production in 2022}_{\text{by value chain}}\ [\text{EUR}], \quad \text{for each 4CEE}$$

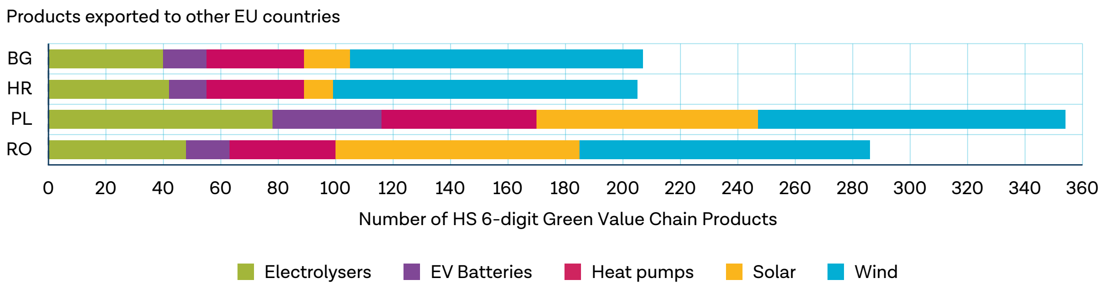
The parts of the product depend on 4CEE country, value chain and scenario. The size of the multiple depends on the value chain and the scenario considered, i.e., whether the NZIA targets are achieved, exceeded or not (see Table 2.1). The onshoring potential sums to one across all HS codes and 4CEEs, so that one 4CEE could take a larger share of the demand increase than the others. The onshoring score is based on 18 indicators across demand, supply, and ease of market access to capture various dimensions relevant to onshoring potential (see Annex B for detail). Principal Component Analysis and k-mean clustering calculate a score and categorize the attractiveness of each product input into 'high' and 'not-high', where only high scores are included among onshoring opportunities. The onshoring attractiveness score (OAS) pinpoints export potential in each of the 4CEEs by value chain and segment. These assumptions imply that the 4CEEs' export potential as a group is held constant as a share of EU member states exports to the rest of the EU. However, the OAS of each country influences what part of the combined market share of the 4CEEs it captures. Details are in Rosenow et al. (2024). Investment requirements are computed using value chain-specific output-capital ratios.

a. And conducted a pilot for leveraging AI to support these complicated high-skill intensive exercises.
b. Rosenow et al. (2024).

30 https://documents1.worldbank.org/curated/en/099936402072438837/pdf/IDU127b390ef1155014bd91aea9110575d799ce6.pdf?_gl=1*1mo1u3x*_gcl_au*NDAxNjQ2NjY3LjE3MjEzMzQ2Njk.

**Poland could benefit from the largest number of opportunities to onshore clean tech product manufacturing, followed by Romania and, to a lesser extent, Croatia and Bulgaria** (Figure 2.8). According to the onshoring attractiveness score (OAS) calculation, Poland's onshoring opportunities are diverse, spanning the EV battery, heat pump and electrolyzer value chains. In contrast, Romania has fewer battery and electrolyzer-related onshoring opportunities. Croatia and Bulgaria have fewer opportunities overall, concentrated in the wind value chain. This disparity may partly be due to the smaller economies of Croatia and Bulgaria, with populations under 4 and 7 million, respectively; Romania has 19 million and Poland 34 million inhabitants, and both are high-income economies. Overall, this analysis indicates that all 4CEEs may have opportunities in every single value chain, but their OASs point to differences in strength for each country across value chains.

**FIGURE 2.8** **Number of onshoring opportunities, by 4CEE country and value chain**




*Source:* World Bank calculations.

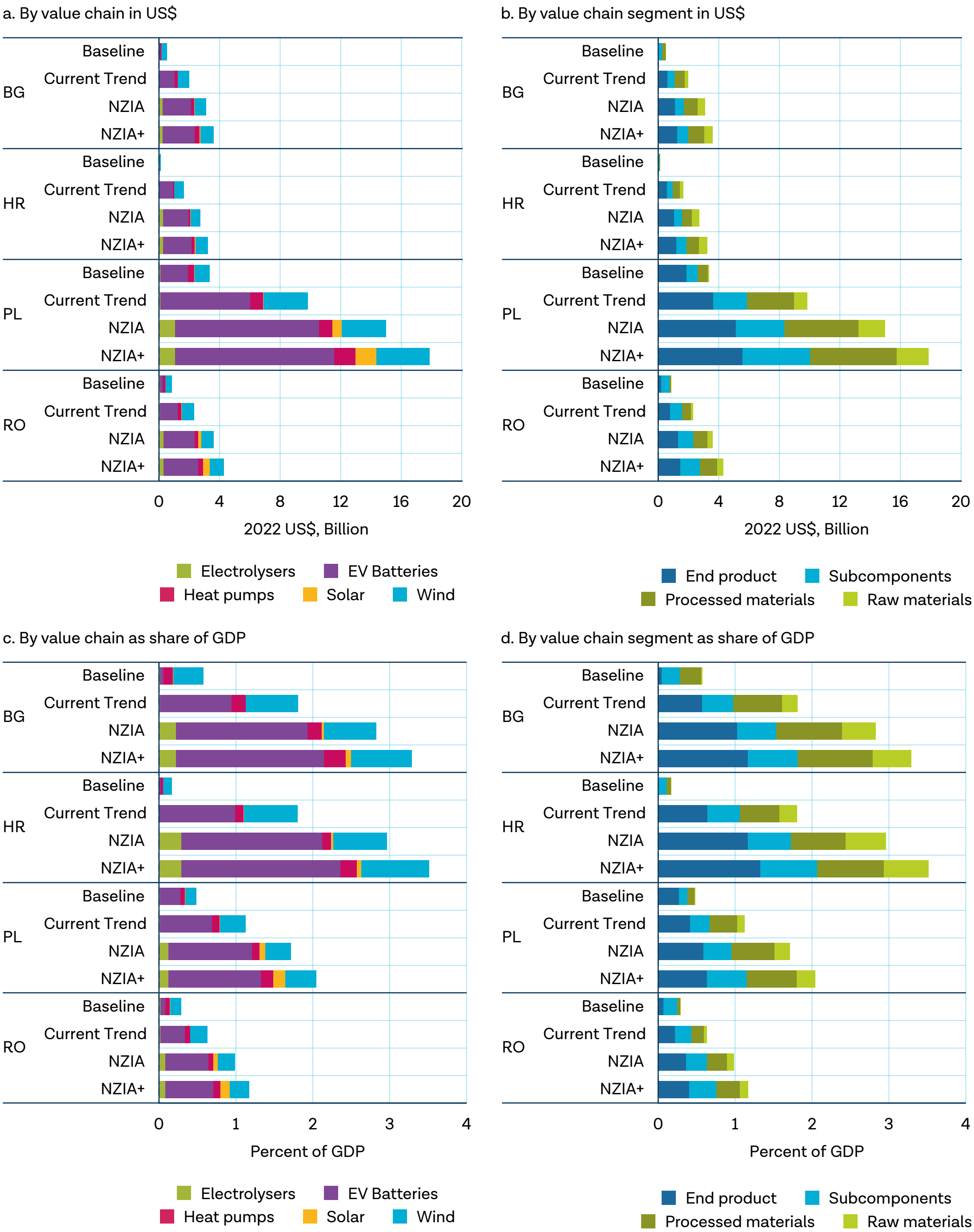
**Simulations show that clean tech value chain exports from the 4CEE countries to the EU27 could increase considerably by 2030.** Starting from modest levels in 2022, when only Poland exceeded US$3 billion in exports and the other countries remained below US$1 billion, all the EU's 2030 scenarios envisage significant growth. In the current trend scenario, where the EU production continues to account for the same market share as in 2022, 4CEEs exporters could triple (Poland, Romania), quadruple (Bulgaria) or grow their exports more than 10-fold (Croatia) from 2022 levels (Figure 2.9, panels a – b). The more ambitious NZIA scenario forecasts even stronger growth, with exports growing more than quadrupling in Poland, and Romania, growing sixfold in Bulgaria and more than 20-fold in Croatia. Complete onshoring under the NZIA+ scenario would make a lesser difference because the NZIA scenario already envisages onshoring a large share of production (see Table 2.1).

**Poland is projected to capture the lion's share of additional onshoring for export products in all scenarios.** Given its extensive portfolio of products well-suited for onshoring, Poland is projected to capture 60 percent of the 4CEEs' exports in a NZIA scenario, mostly in the EV value chain and in end-products (Figure 2.10). In contrast, Romania, Bulgaria, and Croatia are projected to gain considerably less, with similar levels of additional exports between them. Romania presents an interesting case: despite having a higher baseline of 2022 exports than Bulgaria and Croatia, it fails to convert this advantage into higher export projections. This underperformance can be attributed to two factors: limited opportunities in battery production (Figure 2.8), a value chain where EU manufacturing is set to expand significantly; and despite diverse opportunities for product onshoring, a narrow range of EU export destinations that restricts Romania's export growth potential.

**Similarly, the contribution of clean tech exports to GDP could also expand, with variation across scenarios and countries.** Historically, exports in the five clean tech value chains amounted to less than 1 percent of each 4CEE country's GDP. Scenario-specific shares by 2030 can be obtained by combining the absolute export values with World Bank GDP growth projections. By 2030, clean tech exports' share of GDP in a current trend scenario would grow to between 1 and 2 percent, although remaining below 1 percent in Romania (Figure 2.9, panels c – d). A NZIA scenario would bring the share in Romania to 1 percent of GDP, and to nearly 4 percent in Bulgaria and Croatia. Poland's clean tech exports are projected to reach 2 percent of GDP. This positions Poland's growth in green value chain exports relative to GDP in line with its regional peers, even as it maintains its dominant position in absolute terms.

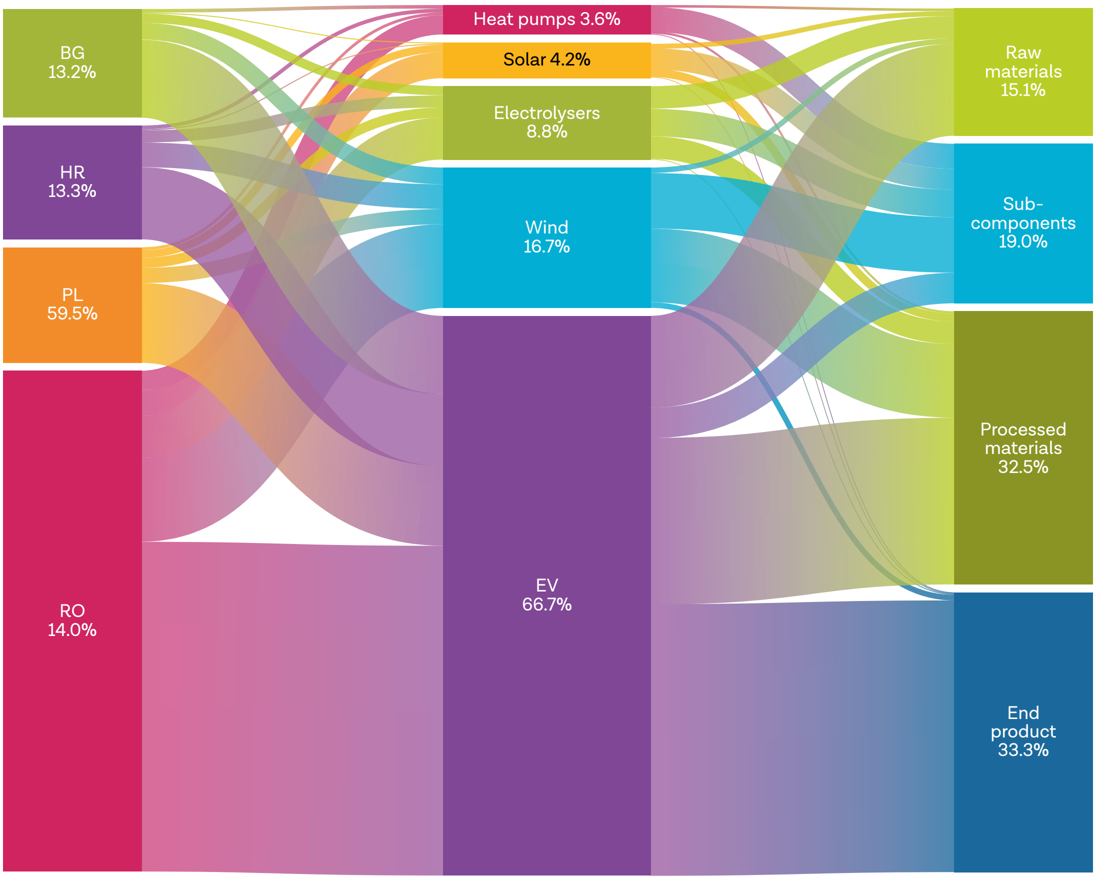
**FIGURE 2.9 Export projections, by 4CEE country and onshoring scenario**

(Export to other EU countries)




*Source:* World Bank calculations.

**FIGURE 2.10 Distribution of exports of onshored products in NZIA scenario, by 4CEE country, value chain, and segment**




*Source:* World Bank calculations.

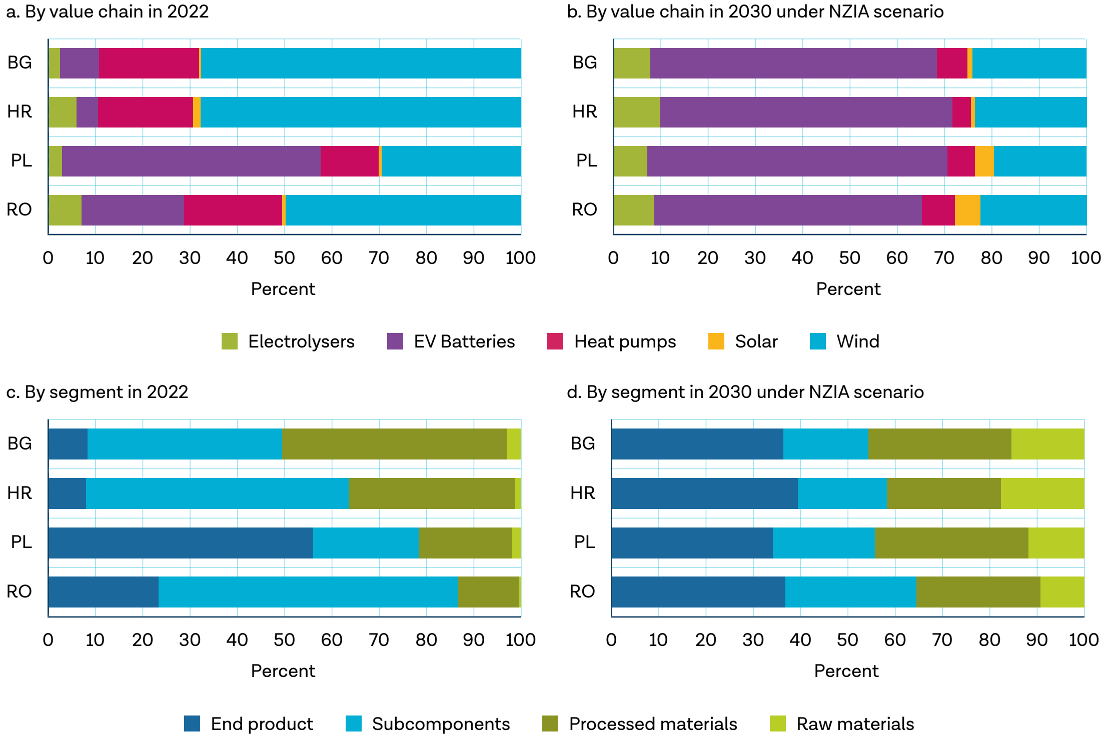
**EV battery exports are projected to grow the most, and become the most important value chain for all 4CEE exporters** (Figure 2.11, panels a – b). This dominance is driven by the sevenfold growth target set in the NZIA and the sector's substantial value addition, with batteries accounting for 30 – 40 percent of an EV's total value added.[31] This simulated battery export growth highlights the potential economic impact of Europe's automotive industry transition to EVs on Central and Eastern European exports. The outlook varies for other value chains. Wind energy presents onshoring opportunities across all four 4CEEs. In contrast, the solar PV value chain's prospects differ significantly: Poland and Romania show potential for onshoring solar PV production, while Bulgaria and Croatia have limited opportunities.

**The simulated composition of exports by value chain segment shows that all countries have potential to expand production across the segments of value chains.** Notably, Bulgaria, Croatia and Romania all have the potential to increase their share of end product manufacturing, and Poland its share of material processing, relative to current shares (Figure 2.11, panels c – d). These results illustrate that the simulations show a potential export composition, not a specific prediction. Ultimately what is being produced in any given country at much larger scale than today depends on decisions to locate factories for manufacturing particular products, and — potentially — mines for raw materials.

31 IEA (2022), Global Supply Chains of EV batteries.

**FIGURE 2.11 Export share in 2022 and under the NZIA scenario, by 4CEE exporting country**

(Export to other EU countries)




*Source:* World Bank calculations.

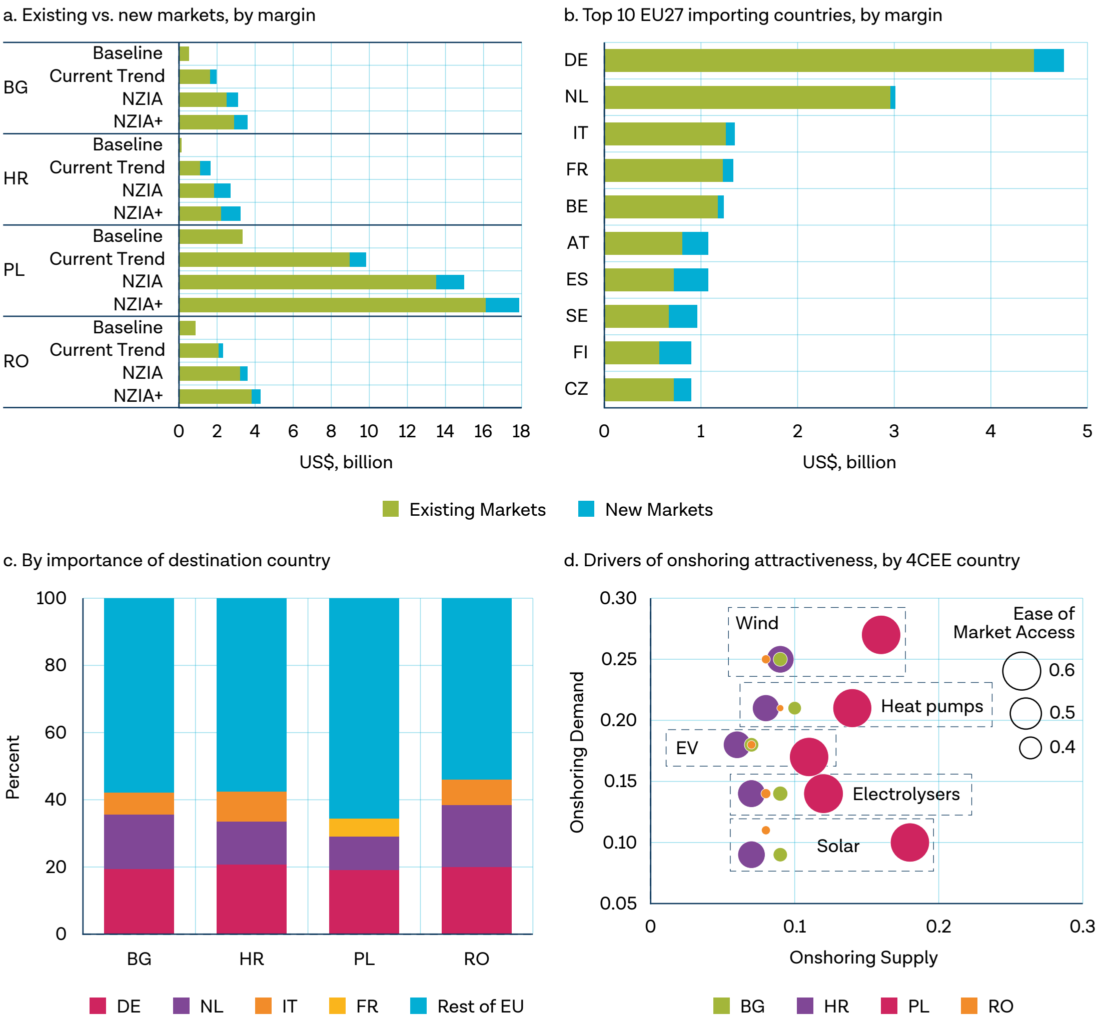
**Clean tech exports from the 4CEEs are expected to largely service demand from major EU importers.** This pattern is evident in the established trade relationships between these four countries and their key destination markets (Figure 2.12 a), particularly Germany and the Netherlands (Figure 2.12, panel b) — both major importers of clean tech products. However, certain onshoring opportunities can create new trade relationships within the EU. Croatia stands out in this regard, as our simulations envisage that it will direct as much as one-quarter of its 2030 exports to currently unserved export markets in a NZIA scenario. In contrast, Romania is projected to reach fewer new export destinations than its peers. This limited expansion may be a key reason behind Romania's struggles to convert its clean tech value chain diversification into substantial export gains.

**For all 4CEE exporters, around 40 percent of exports are projected to target three large Western European importers: Germany, the Netherlands, and Italy** (Figure 2.12, panel c). Poland has the most diversified group of importing countries, while Romania has the least diversified. Poland's strong appeal for onshoring stems from its superior supply capabilities and ease of market access relative to its peers. This advantage extends across all five clean tech value chains, particularly in wind and solar PV products (Figure 2.12, panel d).[32]

32 Limited variation in onshoring demand scores across 4CEE countries stems from our use of demand indicators that are common to all of them.

**FIGURE 2.12** **Projections of exports by type of importer under NZIA scenario; decomposition of drivers**

(Export to other EU countries)

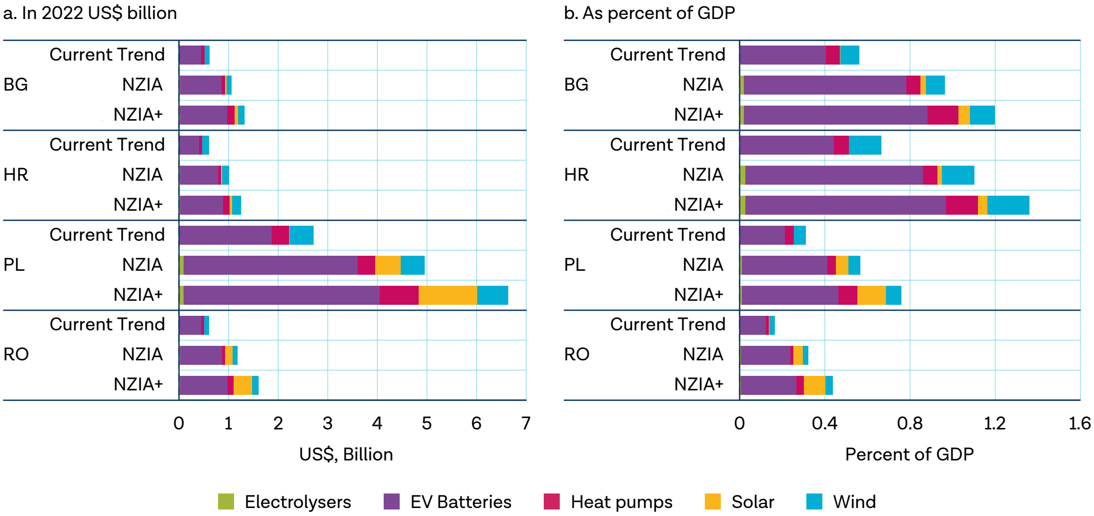



*Source:* World Bank calculations.

**Such a potential scale up in production would require substantial upfront investments, particularly from the private sector.** Capital expenditure (Capex) for acquiring, upgrading and maintaining assets is projected to range from US$1 billion in Bulgaria, Croatia and Romania to US$5 billion in Poland (Figure 2.13, panel a). Since construction of new manufacturing facilities often takes several years, these investments would need to be initiated in the near term to ensure operational readiness before 2030. Although substantial, such investments are smaller than the funds Romania has already committed under the Temporary Crisis and Transition Framework to subsidize wind and solar farm deployment (Figure B1.4.1); moreover, part or all of these investments should originate from the private sector. However, these requirements add to substantial investment needs in decarbonization and adaptation by both the private and public sectors.[33] Section 2.5 provides insights into the key drivers for the investors in clean tech manufacturing and deployment. As a share of GDP, investment requirements are larger in Croatia and Bulgaria, in line with higher export-to-GDP ratios (Figure 2.13, panel b).

33 World Bank (2023). Romania Country Climate and Development Report. The World Bank Group.
World Bank (2024). Poland Country Climate and Development Report. The World Bank Group.

**FIGURE 2.13 Estimated capital investment needs for additional manufacturing capacity**




*Source:* World Bank calculations. Capex represents cumulative investment needs between 2024 – 2030 to enable growth in exports.

**The simulations show that an ambitious implementation of the NZIA onshoring targets could open up sizeable opportunities to export manufacturing products for the 4CEEs, in the absence of disproportionate incentives or other targeted policies in other EU member states.** All 4CEEs could have opportunities to grow existing clean tech export lines and add new ones, and some of them can reach new markets within the EU. The simulated size of additional potential clean tech exports indicates worthwhile opportunities, especially if they lead to competitiveness in markets beyond the EU, which the gravity model identifies as relatively underserved. However, these illustrative results rest on the assumption that the 4CEEs can raise the required financing domestically or attract FDI, and more importantly, that there is no disproportionate targeted policy competition from other EU member states, states, in the form of incentives or other efforts to attract producers.

# Understanding firm-level networks in the 4CEEs

**Ultimately, value chains operate at the company level.** While sectoral analysis — even as fine-grained as the Harmonized System in the previous subsections — offers valuable insights into what countries export, it cannot be detailed enough to ascertain whether a country's firms participate in a particular step of a specific value chain. For instance, in the heat pump value chain, a refrigerant is produced. Countries exporting refrigerants are strong candidates for participating in the heat pump value chain, but it is not possible to verify, relying on export classifications only, whether the refrigerant is used in a heat pump (and thus part of the clean tech value chain), an air conditioning system or a refrigerator (not part of the clean tech value chain), or in all three products.[34] Starting from a list of (often pioneering) firms with well-documented engagement in certain clean tech business activities and tracing their supplies allows to rule out accidental association via imprecise export classification. Therefore, complementing sectoral analysis with firm-level customer-supplier relationships is desirable for a more complete picture of current value chain networks.[35]

34 Please note that the simulations in the previous section included scaling the volumes accordingly in order not to over-estimate the overall volumes of export opportunities.

35 Previous sections defined net zero value chains as those that produce equipment for producing or using low-carbon energy (or what the EU calls net zero technologies). This excludes value chains producing anything (say steel or clothing or peaches) with a low carbon-footprint.

**Network analysis helps understand dynamic and complex underlying trade patterns in increasingly intertwined global value chains.** The COVID-19 pandemic exposed global supply chain interconnectedness; and, together with recent geopolitical developments and the increased ambition of the climate agenda, induced shifts in the global buyer-supplier networks. Network analysis has become essential for understanding global economic intricacies, especially in interdependent supply chains. Traditional models often miss the dynamic, complex relationships in modern trade networks. In contrast, network analysis reveals detailed patterns of trade, influence, and dependency. In the clean tech value chains, network analysis is particularly relevant for understanding how end products (such as wind turbines or batteries) rely on a network of suppliers located in a variety of countries, adding complexity to economic interactions. By mapping firm connections, researchers can identify key players and assess their influence on diffusing clean energy technology. Central firms may drive significant changes by influencing suppliers and customers, amplifying their initiatives' impact.

**The participation of firms from Central and Eastern European countries in the clean tech manufacturing value chain is crucial for the EU Green Transition.** These countries, though late developers, are deeply integrated into EU and global supply chains (Box 1.4). Network analysis helps visualize and quantify their roles, highlighting their centrality and connectivity. This is essential for policymakers and business leaders aiming to foster more inclusive and sustainable economic growth.

**This section leverages network analysis to describe the interconnectedness of firms within global clean tech value chains, with a focus on Bulgarian, Croatian, Polish, and Romanian firms** (see Box 2.4 for details). It aims to map and visualize the inter-firm network, highlighting the roles and centrality of these countries, their degree of integration, the nature of their relationships, and their potential to drive or adapt to sustainable practices. Additionally, it suggests that further work could focus on the network's evolution, identifying patterns in link formation and dissolution, assessing how these dynamics are influenced by firm, industry and country characteristics, and how they affect in turn the overall sustainability and resilience of the global supply chain.

### BOX 2.4 Analysis of firm networks in clean tech global value chains firm: definitions and methodology

**Clean tech value chains definition:** The global economy is interconnected through a vast network of firms linked by supply relationships. Within this network, the clean tech value chain involves a substantial number of firms participating in the production of low-carbon goods, services, and technology. This global ecosystem encompasses a diverse array of industries and sectors that are linked through supplier-buyer relationships, and where the business focus is on reducing greenhouse gas emissions, enhancing energy efficiency, and fostering innovation in green technologies. This analysis uses a firm-based approach to define clean tech value chains, where a network of supply-chain connected firms is derived around a core set of firms with well documented green business or investment activities. These core firms were identified using a Financial Times fDi Markets data base filtering for 'Green Technology' and AI-supported detection of lead firms in reports on specific clean tech manufacturing value chains. Thus, the sample is tilted towards larger, internationally connected firms, and conditional on availability of information in the supply chain dataset used. Subsequently, the clean tech value chain is defined as encompassing all companies that maintain customer or supplier relationships with any of the identified core green entities. As the buyer-supplier relationship moves further away from the initial list of firms, any particular firm's involvement in clean tech can become diluted, and thus should be taken with caution (e.g. the end consumer/buyer of selected clean tech goods, such as parts of wind turbine components, partly manufactured in 4CEEs, may be an international firm with interests in deployment of renewables and other, non-clean tech or even fossil fuel-related equipment). To balance the risk of false positive connections with the desire to include all clean tech value chain-relevant partners, only firms with at least one direct connection to a clean tech core firm are included in the network. Put differently, firms that are the supplier of a supplier to a clean tech core firm are excluded from the network, unless they are a customer or supplier of another clean tech core firm.

**Network Analysis Tools:** For detailed network computations, this analysis uses Python's NetworkX library, which provides advanced functionalities for calculating various network metrics (see below). These are complemented by several statistical measures to quantify network properties and understand the roles of individual firms and countries within the clean tech value chain. For visualization, this analysis uses Gephi, an open-source network visualization and analysis software. Gephi's capabilities allow for creating visually intuitive graphs that depict firm relationships. A force-directed algorithm positions nodes (firms) closer if they are directly connected, facilitating the visual identification of clusters and key players within the clean tech value chain. By applying these statistical measures, we can map out the structure of the clean tech value chain, identify key actors and clusters, and assess the potential for the propagation of sustainable practices and technologies. The combination of detailed data sources, robust analytical tools, and comprehensive statistical measures ensures a thorough analysis of the interconnectedness of firms within the global clean tech value chain.

**Key metrics:**[a]

- **Degree Centrality** (many direct connections): Measures the **number of direct connections** a firm has, i**ndicating its influence and importance in the clean tech value chain.**
- **Betweenness Centrality** (critical intermediaries): Quantifies how often a firm appears on the shortest paths between other firms, highlighting its role as a **critical intermediary** in the network. Betweenness centrality and shortest path can be effectively illustrated with an analogy (following Carvalho et al.):[b] consider a system of pipes through which water flows; the shortest path is the shortest distance between nodes in this system, i.e. the shortest route for the water to reach a destination from a given source. A node with high centrality is one that, if blocked, will significantly reduce the total flow of water in the entire system, not just to the immediate destinations connected to that node. In our case, **a critical intermediary (i.e., a firm with high betweenness) is a firm that, if removed from the network, can significantly alter the productive capacity of the remaining firms and potentially reduce output in the entire system.** Importantly, betweenness centrality takes indirect linkages into account, as it assesses whether the shortest connecting path between any other two firms in the network passes through a given firm.
- **Community Detection:** Uses algorithms like modularity maximization to detect clusters or communities within the network, helping to understand how firms group together and their potential for localized influence on sustainability practices.

**Data:** The primary data source for the analysis in this section is the FactSet Revere Supply Chain Relationships database, which provides comprehensive firm-level data on financial performance, demographics and supply chain relationships. FactSet's extensive coverage includes detailed information on firms' interactions, predisposing it for mapping value chain networks.[c] The initial set of companies was extracted from the Financial Times FDI database and reports (see top of this box). Among these, a total of 614 initial clean energy technology entities could be matched with FactSet's 2023 supply chain database. These 614 companies link to an additional 1758 companies in their corporate families, i.e., subsidiaries or parent companies. Together, these firms are called 'key companies' or core clean tech firms. FactSet then allowed to identify their customers and suppliers, increasing the number of firm nodes to 17,946. Supplementary data from the Orbis and EMIS databases may be utilized in future iterations to enhance the robustness of the analysis, offering additional insights into the characteristics and financial health of firms, especially those in the 4CEE countries.

a. Other metrics often used in the literature are graph distance (number of nodes in between two firms linked by a path), and network density, the number of actual edges divided by the potential unique edges in a network.

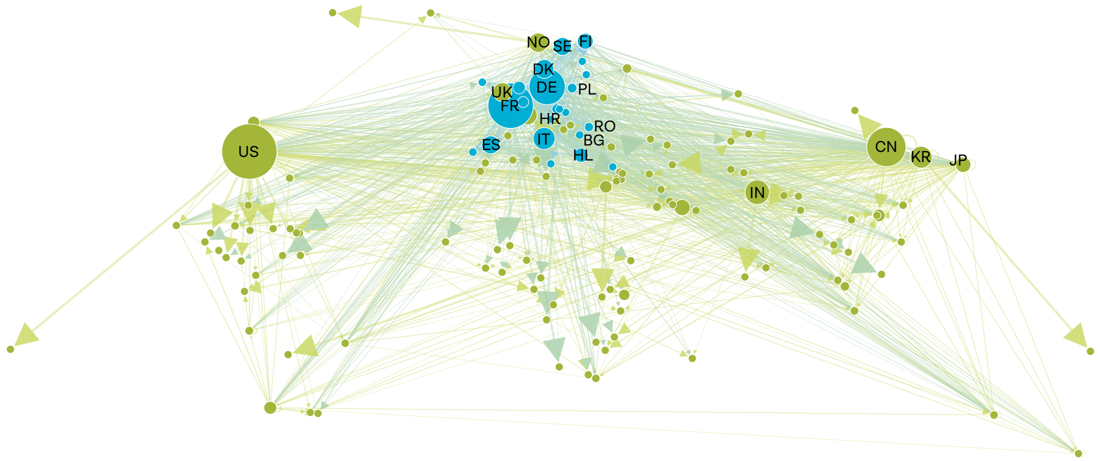
b. Carvalho, Vasco M., Matthew L. Elliott, and John Spray, "Network Bottlenecks and Market Power," Mimeo, In Progress.

c. Documenting over 1 million supplier and customer connections on a global scale, FactSet is the most comprehensive global collection of supply chain linkages to date. Still, it does not represent a firm census. In general, the sample is biased towards large, publicly listed entities. Comparing supply chain data with Eurostat's latest economy-wide enterprise counts in, the relative sample representation of the 4CEEs is generally consistent with the latter. Croatian firms tend to be marginally oversampled, while Romanian firms are somewhat underrepresented.

**Countries across the globe — including those in the EU — are highly integrated into clean tech global value chains, highlighting risks from the rise of inward-looking policies.** Figure 2.14 depicts between-country connections in buyer-supplier relationships in clean tech value chains. Light blue nodes represent EU buyers/suppliers, beige nodes represent non-EU buyers/suppliers. The arrows indicate the direction of the buyer-seller relationship, with the arrow pointing toward the customer. The thickness of the arrow reflects the number of suppliers from a given origin relative to the total number of suppliers to the destination country — i.e., the relative importance of the supplier's origin to the destination country. The multiple arrows and their thickness indicate a highly integrated global value chain for the manufacturing of green technologies. Greater use of protectionist trade policy by individual countries or regional trade blocs would risk severely weakening — or even severing altogether — such global linkages.

**FIGURE 2.14 Clean tech value chains are closely intertwined globally**

Network representation of buyer-seller relations, country aggregates, global level



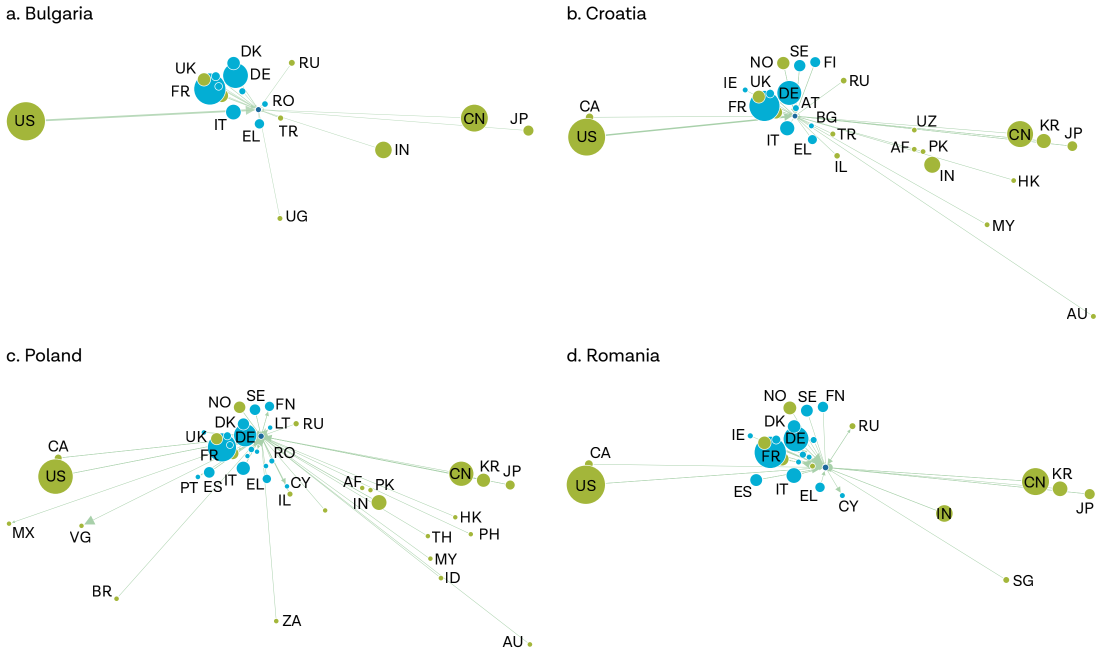

*Source:* World Bank calculations using FactSet.

*Note:* Blue nodes represent EU buyers/suppliers, green nodes are non-EU buyers/suppliers, with each node geolocated at the country's coordinates. The arrows indicate the direction of the buyer-seller relationships, with the thickness of the arrows representing the relative importance of the supplier origin to the destination country. The size of each node reflects the betweenness centrality (i.e., the number of shortest paths through the node).

**EU countries are collectively involved in clean tech value chains, with considerable variation among them.** Several EU country nodes are among the most central in the network, and the large size of some of them — notably, France and Germany — underscores their crucial role in connecting different parts of the network, rivalled only by the United States and China. On the other hand, the 4CEE nodes are among the smallest in Europe.

**The 4CEEs show different levels of connectedness in the clean tech manufacturing value chains, with Poland standing out for its number of direct connections to other countries.** Figure 2.15 shows only direct connections to each of the 4CEEs, one per panel. This subset reveals that Poland is connected to more countries, resulting in a higher degree centrality. Conversely, Bulgaria, Croatia, and Romania, are less connected. Poland's buyer/supplier network is the largest among the 4CEEs, with connections to suppliers and buyers in 34 and 35 countries, respectively; and the most connected to non-European countries, particularly in North America and East Asia. Bulgaria and Croatia have far fewer, less diverse, and weaker links with other countries (in aggregate, Bulgarian firms have suppliers from 17 countries and buyers from 7 countries, while Croatia has 19 supplier and 19 buyer countries). As such, Bulgaria and Croatia tend to rely more heavily on certain key international partners for their clean tech supply chain linkages, and have room to enhance their connectivity and influence within the network — including by emulating Poland in building a richer domestic ecosystem. For its part, Romania is connected to buyers and sellers in 21 and 24 countries, respectively.

**FIGURE 2.15 The 4CEEs differ in their levels of connectedness to other countries in clean tech value chains**




*Source:* World Bank calculations using FactSet.

*Note:* Blue nodes represent EU buyers/suppliers, green nodes are non-EU buyers/suppliers, and the relevant 4CEE country is in red. The arrows indicate the direction of the buyer-seller relationships, with the thickness of the arrows representing the relative importance of the supplier origin to the destination country. The size of each node reflects the betweenness centrality (i.e. the number of shortest paths through the node.

**Among the 4CEEs, Polish firms emerge as important intermediaries in clean tech value chains** (Figure 2.16). For each of the 4CEEs, Figure 2.16 depicts connections between individual firms in the network—whereby instead of showing a single edge between two countries regardless of the number of firms connected, a new edge is depicted for each individual firm's supplier-buyer relationship. The panels depict the components of the global green tech network that firms in each of the 4CEEs are connected to. Poland (Figure 2.16, panel a) emerges as the most integrated of the 4CEEs and an important intermediary in clean tech GVCs. For example, Poland has as many overall connections as Belgium, but a centrality score more than twice as high (66 versus 28) and closer to those of Australia or Singapore (around 77 and 57, respectively). Yet, although Polish firms are relatively well-integrated into clean tech value chains, some clusters are disconnected, indicating isolated buyer-seller relationships outside the core network. This suggests that a subset of Polish firms remains peripheral, and might take advantage of untapped opportunities for further international integration.

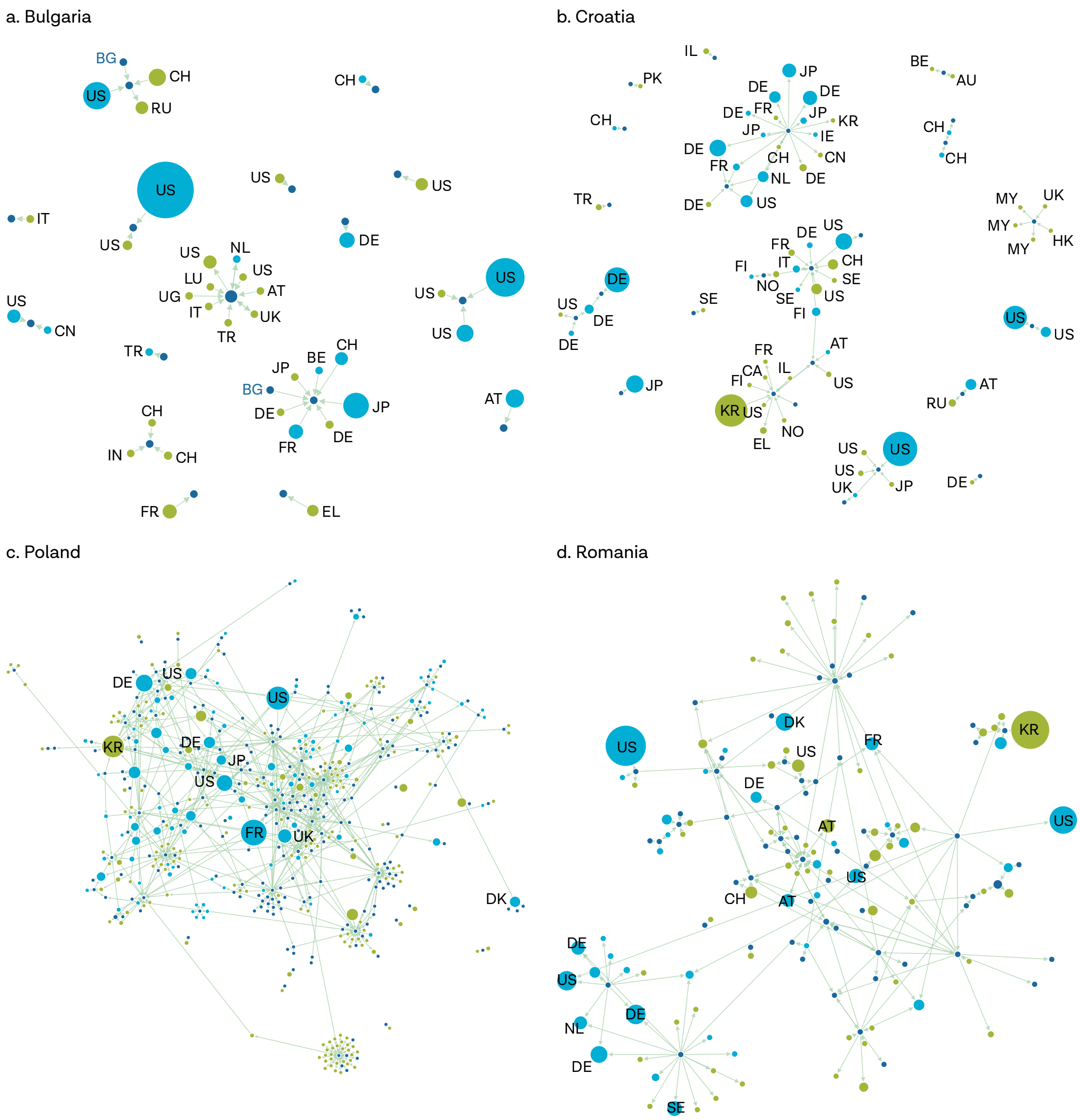
**The firms in Croatia and Bulgaria show potential to boost international connectivity and seize untapped opportunities.** Compared to Poland, firms in clean tech value chains in Croatia and Bulgaria tend to operate on relatively disconnected islands (Figure 2.16, panels b and c). Croatian firms are much less integrated into clean tech value chains than those in Poland and Romania. A similar pattern is observed for Bulgarian firms (Figure 2.16, panel c), although their network at the country level appears slightly more connected than that of Croatia (with a network centrality score of around 13 for Bulgaria versus 2.7 for Croatia).

**Romania stands halfway between Poland on one end, and Bulgaria and Croatia on the other.** Romania's centrality scores are below the EU averages, with few shortest paths going through the country—highlighting

Romania's currently limited role, but also its potential to become more central in clean tech value chains. At the firm level, despite some unconnected components, most Romanian entities are well integrated in their network.

**Bulgaria and Croatia are less connected to clean tech value chains relative to not only Romania and Poland, but also to a non-EU neighbor and competitor such as Türkiye.** The net-zero value chain in Türkiye is dominated by foreign suppliers, which represent 98 percent of the total. However, its overall connectedness is on a par with that of Ireland or Belgium, suggesting that it is an important player and a competitor to EU laggards.

**FIGURE 2.16 Poland is an important intermediary in clean tech value chains, while firms in Croatia and Bulgaria tend to operate on disconnected islands**




*Source:* World Bank calculations using FactSet.

*Note:* Segments of the global green tech value chain that involve 4CEE firms. The green nodes represent a company located in the respective country; the blue nodes represent key companies in the clean tech sector, while the size of each node reflects the betweenness centrality of the companies in the overall network.

**Clean tech firms in the 4CEEs have varying levels of integration into their domestic economies: Poland and Romania have large domestic supplier bases, showing higher potential for job creation, potential policy impact, and investment attraction.** Around 50 percent of the buyer-supplier relationships for firms in green tech value chains operating in Poland and Romania are domestic (52 and 43 percent, respectively) — versus the EU average of 23 percent (Table 2.2). Within the EU sample, only Lithuania (68 percent), and Estonia (58 percent) are more domestically oriented. This signals a higher level of integration of these firms with their domestic economies, potentially higher value addition, and potentially higher spillovers from policies impacting domestic firms' production volumes and input choices (e.g., local content requirements). Analysis adapted from Winkler et al. (2023) also shows that for every direct job in manufacturing overall, the 4CEEs create fewer *indirect* jobs (0.5 – 0.8) than the averages in the EU (1) and in a broader sample of 52 countries (1.6), indicating less-developed domestic supply sectors in the 4CEEs.[36] In this context, the greater reliance on domestic suppliers by Polish and Romanian firms in clean tech value chains may be indicative of their higher job creation potential. As shown in the next section, foreign investors in original equipment manufacturing also prioritize supplier network strength when choosing locations for their manufacturing investments.

**In contrast, most or all supplier relationships for Bulgarian and Croatian firms in clean tech value chains are cross-border, highlighting limited integration with the domestic economy and the importance on focusing on horizontal policies.** Seventy-five percent of the supplier relationships of Bulgarian firms traced in FactSet are international, indicating limited integration of exporters with the rest of the economy. For Croatian firms in clean tech supply chains, 100 percent of the suppliers tracked in FactSet are international (small or one-time purchases may not be tracked by FactSet, which focuses on the major supplier-buyer relationships). This shows not only dependence on inputs from abroad, especially outside the EU, but a lack of integration with domestic suppliers — with potentially higher risks of being replaced with firms from other countries in clean teach production (again highlighting the risks from more protectionist policies).[37] As a result, an expansion of the value chain might have only limited spillovers in the domestic economy, although this cannot be evaluated with this dataset.

**The 4CEEs also differ in the degree of dependence of their firms on specific countries for foreign inputs.** Among the 4CEEs, Poland's buyer-supplier network is the one connected to the most countries, including in the Global South (Figure 2.15). Bulgaria and Croatia display linkages with far fewer countries, despite entirely depending on foreign suppliers. This indicates that their position in the clean tech value chains can be influenced by decision-making in or shocks to a handful of foreign firms in a small number of countries. Romania once again is in the middle.

**Among foreign (i.e. non-EU) suppliers, all 4CEEs have the strongest ties with the US, and within the EU, highlighting the risk from policies that favor EU-based counterparties.** The US is the top foreign supplier in clean tech value chains to all 4CEEs, accounting for between 5.9 percent of supplier relationships in Romania and 27.8 percent in Bulgaria (Table 2.2). The second-largest foreign supplier to the 4CEEs is an EU country, either Germany or France. The importance of the US as a supplier indicates that more inward-looking trade policies at the EU level, which would reduce imports from outside the EU, risk impacting the supply cost curve of clean tech players in the 4CEEs — and may require them to consider steps including re-shoring, finding new suppliers, and/or ceasing operations, with the associated impacts on jobs.

**Looking beyond country-level statistics reveals another layer of complexity of firm-level interaction patterns.** For instance, among Poland's foreign suppliers, the US accounts for 9.3 percent of all buyer-seller

36 Business services created between 0.45 and 0.6 indirect jobs in the 4CEEs in 2005, higher than the average elsewhere in the EU of 0.4, but converged to the EU average by 2019, with Romania still showing a higher multiple. Despite being relatively low, the job multipliers of manufacturing in the 4CEEs are higher than those of other sectors.

37 Operating on many disconnected islands as depicted in Figure 2.14, panel b, there are also limited indirect spillovers from one Croatian firm that indirectly links to another domestic company via a foreign supplier.

linkages of Polish enterprises (49 US companies supplying 28 Polish firms), followed by Germany with 8.3 percent (44 German companies supplying 23 Polish customers), and Japan with 4.7 percent (25 suppliers with nine Polish customers). The pool of US firms is large and diversified, with the top 3 firms accounting for about 38 percent of the linkages. In contrast, Japan, despite having a comparable share of links (4.7 percent), shows a more skewed distribution, with the country's top three suppliers accounting for 64 percent of total transactions. From the point of view of buyers, Polish companies report 534 buyer relationships, of which 277 are domestic and the rest with foreign buyers. Domestic buyers are largely concentrated in the energy sector, accounting for 23 percent of domestic buyer relationships. Among foreign buyers, Germany accounts for 11.9 of Polish companies' foreign transactions, with orders in automobiles, light motor vehicles, and general-purpose machinery manufacturers, followed by France (5.8 percent) and the United States (5.2 percent).

**TABLE 2.2** **Reliance of firms in clean tech value chains on domestic vs. foreign suppliers, by country**

| | Reliance on domestic suppliers | Reliance on foreign suppliers | | | |
|---|---|---|---|---|---|
| | **Reliance on domestic suppliers** (percentage of domestic buyer-supplier relationships vs. total relationships) | **Reliance on foreign suppliers** (percentage of foreign buyer-supplier relationships vs. total relationships) | **o/w from the United States** | **o/w from the top EU supplier** | **other foreign suppliers** |
| Bulgaria | 25.0 | 75.0 | 27.77 | 5.55 | 41.68 |
| Croatia | 0.0 | 100.0 | 22.91 | 14.58 | 62.51 |
| Poland | 52.4 | 47.6 | 9.28 | 8.33 | 29.99 |
| Romania | 43.2 | 56.8 | 5.88 | 6.72 | 44.2 |
| EU average | 23.4 | 76.6 | | | |

*Source:* World Bank based on FactSet data.

**While high-level and descriptive, this analysis raises two considerations for policymakers.** First, the impact of any subsidies under the TCTF or other state-aid schemes may be smaller in Bulgaria and Croatia, as the investment would tend to activate supply chains abroad, rather than trickle down to domestic suppliers. Conversely, investments from industrial policy would be more likely to benefit a broader network of domestic firms in Poland and Romania, all other things being equal. Second, in Bulgaria and Croatia in particular, it is important to understand broader market failures that may limit linkages to important domestic suppliers, when devising any form of targeted policy. For instance, a closer look at SME networks, financial sector development, market entry regulations, and other market dynamics could be helpful. It is also important to note the limitations of the FactSet dataset in capturing buyer-seller relationships, which may be more severe for smaller companies — highlighting the value of additional data collection efforts.

## Factors driving investment in clean tech manufacturing and deployment

**When making investment decisions in clean tech value chains, investors report considering multiple factors, including but not limited to government incentives.** This section aims to identify the main elements influencing the decisions of investors in clean tech value chains in the 4CEEs. It uses a combination of qualitative and quantitative interviews with a small sample of existing and potential investors in selected value chains (battery energy storage systems, heat pumps, hydrogen, and solar panels) in Europe, as well as project developers in their capacity as potential purchasers of clean tech products. The interviews are complemented by a review of existing studies on investment attractiveness in the relevant countries.

**Government incentives and the policy environment play an important role in driving investment decisions in the 4CEEs, but are not among the key factors.** Investors indicate that the major drivers of their decisions about where to deploy green value chain investments are: i) market size and market trends, followed by ii) local energy cost, iii) labor availability/cost, and iv) infrastructure (Table 2.3). Less critical overall, but still important to the decisions of specific firms, are: v – vi) government incentives and policy environment, followed by vii) supplier network strategy, viii) technology and innovation ecosystem, and other factors. The analysis also shows that original equipment manufacturers (OEMs) prioritize factors such as supplier network strength, availability of skilled labor, and R&D ecosystems, while project developers (i.e. those focusing on deployment of clean energy technology, e.g. for clean electricity production) focus more on regulatory clarity, government incentives, and ease of obtaining licenses. Both manufacturers and developers emphasize energy costs, infrastructure quality, and cost of skilled labor, but with distinct needs: OEMs for production efficiency, and developers for project deployment.

**TABLE 2.3 Drivers of FDI in clean technologies into 4CEEs, as ranked by investors and project developers**

| | Driver (#Rank) | Frequency Mentioned | Weighted Score |
|---|---|---|---|
| 1. | Market Size and Prospective Trends | 10 | 26 |
| 2. | Energy Costs | 9 | 22 |
| 3. | Labor Cost/Availability | 8 | 20 |
| 4. | Connectivity and Infrastructure Quality | 7 | 17 |
| 5. | Ease of Obtaining Licenses | 6 | 14 |
| 6. | Direct Government Incentives | 6 | 13 |
| 7. | Supplier Network Strategy | 5 | 12 |
| 8. | Technology and Innovation Ecosystem | 4 | 10 |
| 9. | Cost/Availability of Land or Infrastructure | 4 | 9 |
| 10. | Climate Resilience | 3 | 8 |

*Note:* 3 points were given for 1st factor, 2 for 2nd and 1 for 3rd factor in terms of priority identified by the surveyed companies. Note on Market Size and Prospective Trends as priority among surveyed companies: OEMs rely on larger markets to achieve economies of scale, reduce production costs, and optimize supply chains. For project developers, market size indicates higher demand for renewable energy projects, allowing for more spread of fixed costs, more long-term contracts, and growth opportunities.

**The assessed attractiveness[38] for investments in clean tech varies considerably across the 4CEEs, with Poland scoring highly overall** (Table 2.4). Poland scores 'high' — showcasing strong presence and favorable conditions — on 6 out of the 10 drivers identified, reflecting its larger market size and prospective trends, good quality of infrastructure, supplier networks, innovation system, as well as government incentives and broader policy environment — in line with its high-income, large-economy status. Bulgaria, on the other hand, is the only one of the 4CEEs with a 'low' score on 5 out of 10 drivers, reflecting weak investor presence and less favorable conditions. Romania and Croatia sit in the middle, with a mix of 'high' and 'medium' attractiveness among existing and potential investors in clean tech manufacturing and deployment.

**The results of the targeted surveys are consistent with those of some larger-scale surveys[39] across broader industries — e.g., pointing to a shortage of skilled labor as an emerging bottleneck.** The latest

38 The attractiveness was assessed based on how each country scored against the drivers of FDI.

39 The comparison concerns primarily the findings of firm-level surveys, such as the World Bank Enterprise Surveys. The analysis presented here is not comparable with the World Bank Business Ready (B-READY), because: i) B-READY scores rely on the assessment of specialists, rather than private sector firms; ii) B-READY covers a broader set of topics throughout a firm's lifecycle, while this analysis focuses on attractiveness to foreign investors in clean tech manufacturing and/or deployments; iii) B-READY coverage is global and includes the 4CEEs, but excludes most other EU countries, while this analysis relied on surveys of investors in the EU, including in the 4CEEs.

**TABLE 2.4 Heat map of reported investment attractiveness in the 4CEEs across identified drivers**

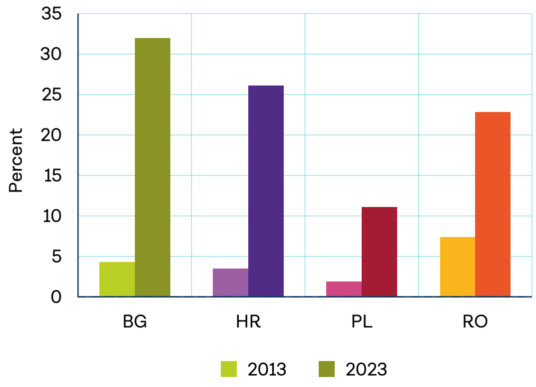
| **Driver** (ranked) | **Bulgaria** | **Croatia** | **Poland** | **Romania** |
|---|---|---|---|---|
| 1. Market Size and Prospective Trends | Low | Medium | High | Medium |
| 2. Energy Costs | Medium | High | Medium | High |
| 3. Labor Cost/Availability | Medium | High | Medium | Medium |
| 4. Connectivity and Infrastructure Quality | Low | High | High | Medium |
| 5. Ease of Obtaining Licenses | Medium | Medium | High | High |
| 6. Direct Government Incentives | Medium | Medium | High | Medium |
| 7. Supplier Network Strategy | Low | Medium | High | Medium |
| 8. Technology and Innovation Ecosystem | Medium | High | High | Medium |
| 9. Cost/Availability of Land or Infrastructure | Low | Medium | Medium | Medium |
| 10. Climate Resilience | Low | Low | Medium | Medium |

High: Strong presence and favorable conditions
Medium: Moderate presence and somewhat favorable conditions
Low: Weak presence and less favorable conditions

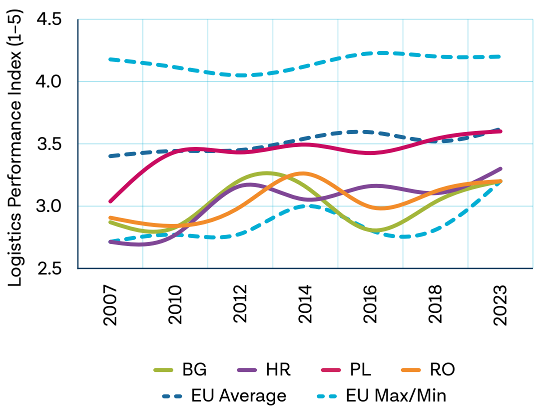
data from World Bank Enterprise Surveys (Figure 2.17, panel a) show that firms increasingly report an inadequately educated labor force among the key obstacles to doing business: it is the most pressing constraint in Croatia and Bulgaria, and the second-most pressing in Romania and Poland. Consistently with migration trends and challenges in education systems, in 2023 between one-quarter (Romania, Croatia) and almost one-third (Bulgaria) of surveyed businesses mentioned a lack of adequate skills as the top obstacle to their activities. Even in Poland, the reported skills shortage rose considerably, to 11 percent in 2019 compared versus 2 percent in 2013. The targeted surveys also echoed the findings of the World Bank's Logistics Performance Index, where Poland scores around the EU average, while Bulgaria, Croatia, and Romania rank among the lowest-scoring EU member states (Figure 2.17, panel b).

**FIGURE 2.17 The findings of targeted surveys in the 4CEEs are consistent with those of other major assessments**

a. Businesses across the economy increasingly report lack of adequate skills as the key obstacle (World Bank Enterprise Surveys, Percent of firms reporting inadequately educated workforce as their biggest obstacle)




b. Poland's logistics infrastructure and processes ranked higher than the other 4CEEs. (World Bank Logistics Performance Index, 2010 – 2023, average score)




*Source:* a. World Bank Enterprise Surveys 2013, 2023; except for Poland, for which the latest data is from 2019. b. World Bank Logistics Performance Index (LPI) https://lpi.worldbank.org/, selected years.

*Note:* The LPI is a weighted average of six key scores: 1) A Customs Score, which measures the efficiency of the clearance process (i.e., speed, simplicity and predictability of formalities) by border control agencies, including customs; 2) An Infrastructure Score, which measures the quality of trade- and transport-related infrastructure (e.g., ports, railroads, roads, information technology); 3) An International Shipments Score, which measures the ease of arranging competitively priced shipments; 4) A Logistics Competence and Quality Score, which measures the quality of logistics services (e.g., transport operators, customs brokers); 5) A Tracking Score, which measures the ability to track and trace consignments; and finally, 6) A Timeliness Score, which measures the timeliness of shipments in reaching destination within the scheduled or expected delivery time." (World Bank Logistics Performance Index. https://lpi.worldbank.org/)

Chapter 3

# Considerations for the policy makers in the 4CEEs: The Why, What and How of (Green) Industrial Strategies

**The findings of this report highlight the importance of an informed and holistic approach to the design of any additional policy or strategy, and of using a broad policy toolkit tailored to the domestic context.** When transposing EU policy shifts into their respective national contexts, policymakers need to be clear about the *why,* the *what,* and the *how* of any potential green industrial strategy or plan (Table 3.1). The why, because if the goals and vision are not clear and specific, it is difficult to strategically direct productive capabilities. The *what,* because while the NZIA and related legislation identify the sectors deemed strategic by the EU, they do so in broad terms — due the breadth of the objectives pursued and of technologies available for decarbonizing the energy sector. This breadth requires member states to adopt a narrower focus, while avoiding fallacy-of-composition risks and other pitfalls of industrial policy. But most importantly, the how: while much public attention concentrates on production subsidies, the industrial policy toolkit is very broad, covering both vertical and horizontal interventions.

**TABLE 3.1** The Why, the What and the How of Industrial Strategies

| 1. Why | 2. What | 3. How |
|---|---|---|
| What is the purpose of the industrial strategy? What vision, goal or mission guides the selection of strategic industries? | What sectors are strategic? How can policy makers identify strategic industries, or productive capabilities? | Which set of policy interventions can effectively support those strategic sectors? |

*Source:* Estevez (2024)

***The Why:* Goal-setting requires specificity, transparency, and caution, while monitoring and adjusting to evolving circumstances.** Without a goal and vision that are clear and specific, it is difficult to direct strategic productive capabilities and avoid one of the common pitfalls of industrial policy design: the selection of too many "strategic" industries.[40] Goal setting is highly context dependent. Historical industrial strategies have often been geared towards economic independence. Similarly, current industrial strategies, as those in the US, frequently place economic security and resilience at the core of their mission. Achieving these goals is increasingly challenging in a context of economic integration, complexity, and instability. Nevertheless, the basic mission of developing a diversified, resilient productive base that includes high value-added sectors remains. This can be achieved in a variety of ways, including by taking advantage of the growth of clean tech manufacturing supply chains.

**While overarching objectives at the EU level have been laid out,[41] member states would benefit from being clear about the national objectives they intend to pursue, while avoiding the 'fallacy of composition'.** Historically, countries have often looked to emerging global export markets for export growth opportunities — but if too many countries pursue the same strategy, focusing on the same set of clean tech products, competition would become stiffer, profit margins tighter, and eventually even high-value-added exports may transform into relatively cheap commodities. Similarly, fiscal and policy implementation capacity for targeted policies may differ across EU member states, with the corresponding differences in their potential ability to drive down the production costs in the industries subject to increasing returns to scale, risking leaving other member states less competitive. Such differences underpin calls for coordinated approaches across EU member states.[42]

***The What:* The NZIA and related legislation identify a broad set of sectors deemed strategic at the EU level, prompting a need for greater focus at the member-state level.** With regional objectives for energy decarbonization guided by multiple security, geopolitical, climate, economic, and social considerations, and with a range of technologies available to pursue them, the portfolio of strategic industries from which to select is correspondingly broad. Furthermore, the increasing complexity of global value chains allows

40 Estevez (2024).

41 The assessment of the EU-level policy direction is beyond the scope of this report.

42 The Future of the Single Market report led by Enrico Letta.

countries to tap into several of them across various stages of production (e.g., by producing sub-components rather than final goods), multiplying the opportunity space. Thus, understanding productive and/or exporting capacities and constraints at the national level is crucial when designing industrial strategy.

**There can be multiple targeting criteria for sector selection, depending on the priority objectives.** Such criteria include: 'ecosystemic' considerations, such the global public good agenda of tackling climate change or preserving local biodiversity; 'economic' considerations, such as potential for demand growth, or the expansion of opportunities for job creation or upgrading; and/or 'political' considerations, such as the level of support from different societal actors.[43] Even when pursuing a relatively narrow objective such as increasing exports, multiple approaches to sectoral selection can be applied.[44]

**Table 3.2 proposes a typology of industry-targeting criteria across three broad categories, adapted from Estevez (2024), depending on the primary objectives of policymakers.** Specifically, the key questions guiding the industry selection can be grouped into three areas: i) Ecosystemic and human health criteria; ii) Economic, productive, and technological criteria; and iii) Political and social criteria. Transparently selected criteria would, in turn, shape the analytical underpinnings for decision-making. For instance, if the guiding objectives for national industrial strategy are job creation or upgrading, and technological upgrading of an existing industry (falling broadly under economic criteria 4 and 5 in Table 3.2), the corresponding analysis would assess the relevant opportunities across a range of sectors.

**TABLE 3.2** **The What. Typology of criteria for industrial targeting**

| | |
|---|---|
| **Ecosystemic and human health criteria** | 1. Environmental impact of the industry and indirect effects on people's livelihoods, locally and globally |
| | 2. Risk factors created by ecosystemic changes: e.g., how will climate change affect a particular industry? |
| | 3. Windows of opportunity created by the emergence of new technologies related to climate change or other projected ecosystem changes. |
| **Economic, productive, and technological criteria** | 4. Potential to generate quality work opportunities in the short and long run, including opportunities for learning by doing |
| | 5. Productive diversification and upgrading through linkages, knowledge spillovers, and skills transposition: Potential to stimulate other industries through consumption linkages (demand generated by workers for consumer goods); forward linkages (industries that may use the targeted industry's outputs); backward linkages (demand for raw materials from other industries); and transposition of skills to seemingly "un-linked", more technologically sophisticated sectors. |
| | 6. Technological requirements: how difficult will it be to create the technological capacities to succeed in the selected industry? |
| | 7. Demand factors: high income elasticity of demand, fast growth in global demand, potential domestic demand through substitution of imports |
| | 8. Potential to secure investment/financing |
| | 9. Potential to generate foreign exchange reserves and manage trade and balance-of-payments risks |
| | 10. Challenges and opportunities created by emerging changes in outsourcing strategies of global firms and market structure of global production networks |
| | 11. Fallacy of composition risks: what industries are being promoted by other countries and how likely is it that a particular product will become 'commoditized', as observed in low-tech manufacturing? |
| **Political and social criteria** | 12. Potential to secure buy-in and collaboration from different societal stakeholders |
| | 13. Potential to increase economic participation by marginalized groups and reduce poverty and inequality |
| | 14. Policy constraints imposed by global economic rules (e.g., trade and investment agreements) or geopolitical pressures |

*Source:* Adapted from Estevez (2024).

43 Estevez (2024).

44 Reed (2024).

***The How:* While public attention tends to focus on production subsidies, the industrial policy toolkit is very broad, covering both vertical and horizontal interventions.** Industrial policy aims at changing the structure of the economy in certain directions; therefore, it refers to all the measures targeting structural change. While recent public discussions tend to focus on subsidies (and, to some extent, on tariffs as a defense against alleged subsidies elsewhere), the relevant policy toolkit is much broader.[45] Moreover, an individual policy's effectiveness can depend on its combination with other policies. For instance, a domestic production subsidy may work better if it is combined with public procurement that favors domestic production.[46] In fact, some have proposed even broader definitions of industrial policy to encompass any policy aiming at changing and improving how societies produce value. [47]

**Figure 3.1 outlines some broader industrial policy instruments, adapted from Criscuolo et al. (2022a) and Estevez (2024), and grouped into supply, demand, and governance instruments.** As structured by Criscuolo et al. (2022a), supply instruments include both policy tools to incentivize individual firms to perform certain actions *(within-firm),* and tools designed to shift resources between firms or industries toward those best suited to fulfill industrial policy objectives *(between-firm).*[48] While supply instruments influence the production of a good regardless of where it is sold, demand instruments influence the consumption of a good regardless of where it is produced. Governance instruments focus on the importance of bodies coordinating policy implementation, the design of forward-looking industrial strategies, as well as the monitoring, evaluation, and correction of the chosen policy mix. Figure 3.1 provides illustrative (but not exhaustive) examples of policy instruments under each category. For instance, state-aid incentives under the TCTF are exclusively supply-focused and within-firm, pointing to the availability of a variety of complementary tools for member states. The NZIA covers certain between-firm areas of intervention, but at the EU rather than state level.

**State capacity is a key factor to determine the relevance of each tool.** Advanced economies with fiscal space and highly developed industrial policy capabilities are more likely to be able to draw on most industrial policy tools. Countries with weak state capabilities, limited policy space, or low investment capacity may find it more difficult to use tools such as large-scale public investment — with carries risks to fiscal sustainability and may be influenced by vested interests in the selection of 'winning' industries — underscoring the importance of careful selection and analysis of complementary policies. Meanwhile, simpler tools — such as using public procurement to generate demand for local industries — are available to most governments, albeit not without risk or costs. Indeed, strengthening state capacity has generally been part and parcel of successful industrial strategies, including because private-sector actors are often ill-suited to taking on ventures that require patient capital and high risk tolerance.

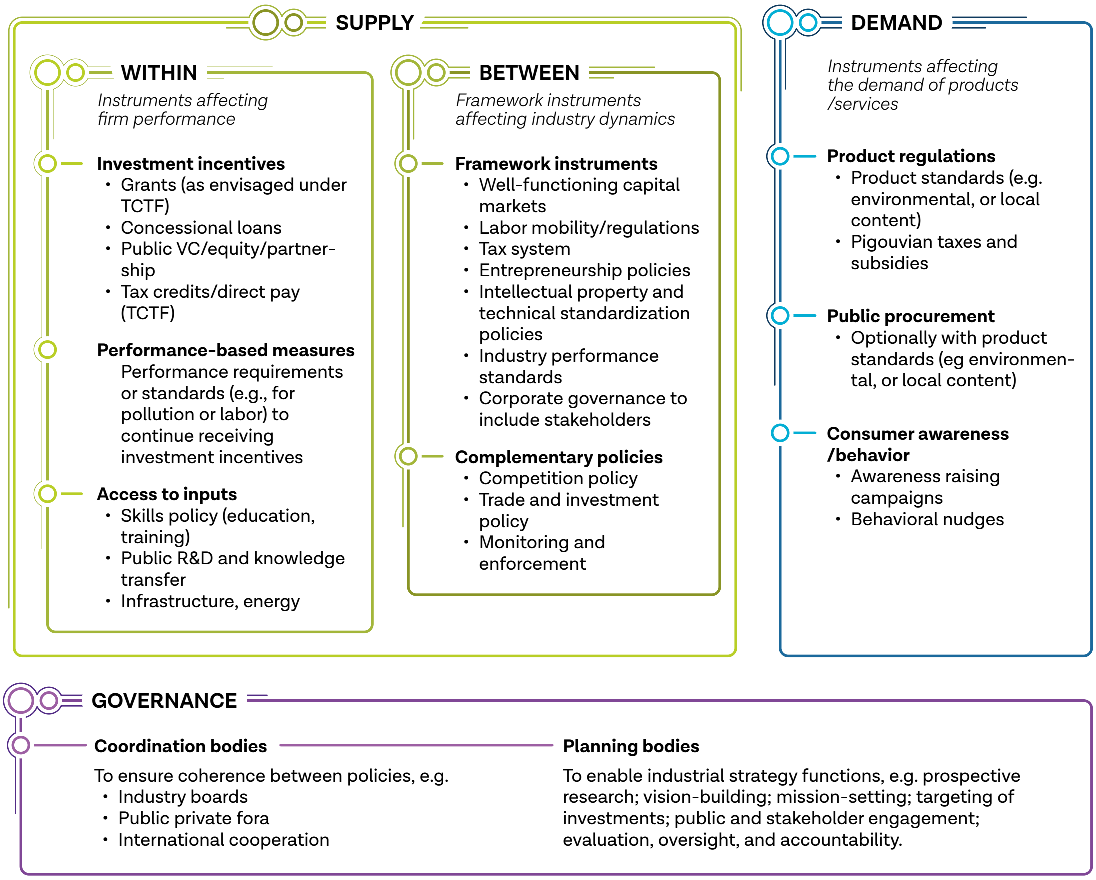
45 Depending on the definition of the industrial policy, there are multiple emerging classifications of industrial policy toolkit. More comprehensive — and anchored in a productivity framework — Criscuolo et al. (2022a) framework is particularly useful. Taking a broad definition of industrial policy, it distinguishes between supply (further distinguishing between tools affecting firm (within) and industry (between) dynamics), demand, and governance components.

46 Letta report 2024. Criscuolo (2022b)

47 A prominent example is the recent work of the OECD which considers industrial policy to encompasses all types of instruments that intend to structurally improve the performance of the domestic business sector — i.e. private sector in its entirety, not just manufacturing (Criscuolo et al. 2022a). There is also variation in how government agencies define industrial policies — stressing vertical policies (as, for instance, in the US) or — until recently in the EU — horizontal policies, see Stiglitz, Lin and Monga (2013).

48 Criscuolo et al. (2022a)

**FIGURE 3.1** Taxonomy of Industrial Policy Tools




*Source:* Adapted from Criscuolo et al. (2022a) for Estevez (2024).

*Note:* The groupings and examples are illustrative and not exhaustive.

# Emerging recommendations

**This report aims to expand the analytical base for complex policy decisions, rather than provide specific recommendations to policymakers in the 4CEEs or the wider EU.** Nevertheless, its analytical findings yield three key insights.

1. **Policymakers in the 4CEEs would benefit from pursuing a nuanced understanding of the policy space in domestic and destination markets, thereby limiting fallacy-of-composition risks.** The analysis in this report illustrates that with growing international fragmentation in the manufacturing of increasingly complex goods, it is harder for governments to target specific products or sectors, especially in priority areas such as green transition, which faces high degree of innovation both at the technical and policy level. Understanding existing market conditions, domestic policies and their interactions, as well as domestic productive capabilities, and their dynamics is critical before adding further vertical or horizontal policies — especially to avoid contradictions between newly proposed and existing measures (a classic example concerns fossil fuel subsidies administered simultaneously with incentives for low-carbon energy, but other cases could apply more directly to clean tech manufacturing). In addition, investing in the understanding of policy, technological, and other developments

in destination markets, as well as of the moves of existing or emerging competitor countries, is paramount to limit fallacy-of-composition risks, while being mindful of opportunity costs is vital to inform any policies targeting specific sectors.

2. **The 4CEEs have room to make use of a broad policy toolkit.** The 4CEEs (except Poland) deploy industrial policy less often than the EU average (perhaps due to fiscal, capacity and/or other constraints), but when they do, they rely almost exclusively on domestic subsidies. Firm-level analysis within the clean tech sector showed that the impact of any subsidies may be smaller in Bulgaria and Croatia, as they would tend to activate supply chains abroad rather than trickle down to domestic suppliers. The broader policy toolkit presented above could complement subsidies with tools targeting the supply and demand sides. On the supply side, this includes performance standards that can attach 'conditionalities' to industrial policies;[49] and between-firm measures such as increasing the availability of skills, improving the functioning of capital markets, and deploying entrepreneurship and innovation policies. On the demand side, available policies include strengthening product standards, enhancing consumer awareness, and tying public procurement to selected conditions. Policies should be selected carefully and in a coordinated fashion, with a view to implementing complementary measures to enhance overall effectiveness. Strengthening governance (e.g., ensuring coherence between policies, and designating enabling bodies) and overall state capacity is important to create the conditions for coordinated policy implementation. Importantly, specific policy strategies should be country- and context-specific.

3. **An EU-level strategy that coordinates national priorities and accounts for place-based industrial policies could benefit all member states.** The analysis has highlighted a risk that all member states try to onshore the same industry, leading to a race to the bottom. The EU could help by taking on, at a minimum, a coordinating and information-sharing role — in line with the recommendations of the recent *The Future of European Competitiveness* report. Recent research[50] estimates that supranational coordination of subsidies for R&D (including in clean tech) yields substantial benefits; and that EU-coordinated policy could result in returns to the EU that are one-fourth higher than those from a combination of nationally optimal policies. A more proactive stance would be possible too, and could benefit from the extensive literature on place-based and regional industrial policy[51] — which aims to locate an industry in a particular location based on uneven eligibility by place or region, and of which the EU has ample experience through its cohesion policies.[52] Moreover, there is evidence that place-based policies work well in tandem with measures enacted by individual member states,[53] such as the creation of local or national investment promotion agencies.[54] The evidence reviewed above indicates that the 4CEEs, and especially Bulgaria, Croatia, and Romania, stand to benefit particularly from place-based industrial policy at the EU level.

49 Mazzucato, M.; Rodrik, D.; (2023) Industrial Policy with Conditionalities: A Taxonomy and Sample Cases. (Working Paper Series 2023 – 07). UCL Institute for Innovation and Public Purpose: London, UK.

50 Martin and Verhoeven (2023).

51 Criscuolo et al. (2019); Grillitsch and Asheim (2019); Soete and Stirna (2023).

52 Crescenzi and Giua (2019).

53 Verhoogen (2023).

54 Crescenzi, Cataldo and Giua (2021).

# References


Amsden, Alice H. Asia's Next Giant: South Korea and Late Industrialization. Oxford University Press, 1989.

Atkin, David, A. Khandelwal and A. Osman. 2019. "Measuring Productivity: Lessons from Tailored Surveys and Productivity Benchmarking". American Economic Association Papers & Proceedings (2019), 109: 444 – 449.

Bernard, A.B., J.B. Jensen., 1995. Exporters, jobs, and wages in U.S. Manufacturing, 1976 – 1987. Bookings Papers on Economic Activity, Microeconomics. Washington DC.

Carvalho, Vasco M., Matthew L. Elliott, and John Spray, "Network Bottlenecks and Market Power," Mimeo, In Progress.

Chang, Ha-Joon. The Political Economy of Industrial Policy. Palgrave, Macmillan UK, 1996.

Cherif, Reda and F. Hasanov. "The Return of the Policy that Shall Not Be Named: Principles of Industrial Policy." March 2019. IMF Working Paper No. 19/74, IMF, Washington, DC.

Coniglio, Nicola D., D. Vurchio, N. Cantore, M. 2021. "On the evolution of comparative advantage: Path-dependent versus path-defying changes." Journal of International Economics, Volume 133, 2021,103522.

Crescenzi, R. and M. Giua. 2019. One or many Cohesion Policies of the European Union? On the differential economic impacts of Cohesion Policy across member states. *Regional Studies*, 54(1), 10 – 20.

Crescenzi, R., M. Cataldo, and M. Giua. 2021. "FDI inflows in Europe: Does investment promotion work?" Journal of International Economics, Volume 132, 2021,103497.

Criscuolo, C., N. Gonne, K. Kitazawa, and G. Lalanne. 2022a. "An industrial policy framework for OECD countries: Old debates, new perspectives", OECD Science, Technology and Industry Policy Papers, No. 127, OECD Publishing, Paris, France.

Criscuolo, C., N. Gonne, K. Kitazawa, and G. Lalanne. 2022b. " Are industrial policy instruments effective? A review of the evidence in OECD countries", OECD Science, Technology and Industry Policy Papers, No. 128, OECD Publishing, Paris, France.

Criscuolo, C., R. Martin, H. G. Overman, and J. Van Reenen. 2019. "Some Causal Effects of an Industrial Policy." American Economic Review, 109 (1): 48–85.

Estevez, Isabel. 2023a. "Using Industrial Policy for Productive Transformation: Lessons from Development Economics for US Industrial Strategy." Roosevelt Institute, May 25, 2023. https://rooseveltinstitute.org/publications/using-industrial-policy-for-productive-transformation/.

Estevez, Isabel. 2023b. "Multi-Solving, Trade-Offs, and Conditionalities in Industrial Policy." Roosevelt Institute, October 26, 2023. https://rooseveltinstitute.org/publications/multi-solving-trade-offs-and-conditionalities-in-industrial-policy/.

Estevez, Isabel. 2024. Industrial Strategy: Methodological Approaches, Lessons, and Pitfalls. Discussion Paper. Unpublished.

European Commission. 2023. Investment needs assessment and funding availabilities to strengthen EU's Net-Zero technology manufacturing capacity. Staff Working Document 68. March, 2023. European Commission: Brussels.

European Commission. 2023. State aid: Commission approves €259 million Romanian scheme under Recovery and Resilience Facility to support investments in batteries, photovoltaic cells and panels. Press Release, Feb 14, 2023. European Commission, Brussels.

European Commission. 2024. The future of European competitiveness. Report. September, 2024. European Commission, Brussels.

European Parliament. 2019. Contribution to Growth: Free Movements of Goods Delivering Economic Benefits for Citizens and Businesses. In-depth Analysis. March, 2019. European Parliament, Brussels.

Evenett, Simon. 2009. GTA 3: The Unrelenting Pressure of Protectionism. Report. December, 2009. CEPR Press, Paris & London.

Grillitsch, M. and B. Asheim. 2018. Place-based innovation policy for industrial diversification in regions. European Planning Studies, 26(8), 1638–1662.

Hidalgo C. A., B. Klinger, A.-L. Barabási, and R. Hausmann. 2007. "The Product Space Conditions the Development of Nations." Science. July, 2007. Vol 317, Issue 5837, pp. 482-487.

Hidalgo, Cesar. 2023. The policy implications of economic complexity. Research Policy, 52(9), p.104863. https://www.sciencedirect.com/science/article/abs/pii/S0048733323001476

IEA, 2022. "The Future of Heat Pumps", World Energy Outlook Special Report, 2022, Paris, International Energy Agency.

IEA, 2022. Global Supply Chains of EV Batteries. Paris, International Energy Agency.

IEA, 2023. World Energy Outlook 2023. Paris, International Energy Agency.

IEA, 2023. *Energy Technology Perspectives, 2023.* Paris, International Energy Agency.

IEA, 2024. "Renewables 2023 Analysis and forecast to 2028". Paris, International Energy Agency.

Juhász, R., N. J. Lane, and D. Rodrik. 2024. "The New Economics of Industrial Policy," Annual Review of Economics 16, 2024, Vol. 16:213-242 (Volume publication date August 2024), San Mateo, California.

Juhász, R., N. J. Lane, E. Oehlsen, and V. C. Perez.2022. "The Who, What, When, and How of Industrial Policy: A Text-Based Approach." Center for Open Science.

Letta, Enrico. 2024. "Much more than a market. Speed, Security, Solidarity: Empowering the Single Market to Deliver a sustainable suture and prosperity for all EU citizens." April, 2024. European Council: Brussels.

Martin, Ralf and D. Verhoeven. 2023. "Knowledge spillovers from clean innovation. A tradeoff between growth and climate?". July, 2023. CEP Discussion Paper No. 1933. Center for Economic Performance, London.

Mazzucato, M. and D. Rodrik. 2023. Industrial Policy with Conditionalities: A Taxonomy and Sample Cases. Working Paper Series, 2023-07. UCL Institute for Innovation and Public Purpose: London, UK.

Mealy, P. A. and A. Teytelboym. 2022. "Economic Complexity and the Green Economy. Research Policy, Volume 51, Issue 8, 2022, 103948.

Mulabdic, A. and Y. Pinar. 2021. Gravity Model–Based Export Potential: An Application to Turkey. Policy Research Working Paper, No. WPS 9557. The World Bank: Washington, DC.

Ohnsorge, F. and Quaglietti, L. "Trade as an Engine of Growth: Sputtering but Fixable." Policy Research Working Paper, 10356. The World Bank: Washington, DC.

Reed, Tristan. 2024. "Export-Led Industrial Policy for Developing Countries: Is There a Way to Pick Winners?" Policy Research Working Paper; 10902. The World Bank: Washington, DC.

Rosenow, Samuel, Sarur Chaudhuri, Gregor Semieniuk, and Emilija Timmis. 2024 forthcoming. Clean tech manufacturing opportunities in Central and Eastern Europe. Export and Investment Implications World Bank Policy Research Working Paper, World Bank, Washington, DC.

Rosenow, S. K., and P.A. Mealy, 2024. "Turning Risks into Reward Diversifying the Global Value Chains of Decarbonization Technologies." Policy Research Working Paper Series 10696. The World Bank: Washington, DC.

Soete, L. and J. Stierna. 2023. *Revisiting Schumpeter in Europe: Place-based innovation and transformative industrial policy.* UNU-MERIT. UNU-MERIT Working Papers No. 022.

Stiglitz, Joseph E., J. Y. Lin, and C. Monga. 2013. "The Rejuvenation of Industrial Policy." September, 2013. World Bank Policy Research Working Paper No. 6628, World Bank, Washington, DC.

Verhoogen, Eric. 2023. "Firm-Level Upgrading in Developing Countries." *Journal of Economic Literature,* 61 (4): 1410–64.

Wagner, Joachim. 2007. "Exports and Productivity: A Survey of the Evidence from Firm-level Data." January, 2007. The World Economy, Volume 30, Issue 1, p. 60-82.

Winkler ,Deborah E, Hagen Kruse, Luis Alejandro Aguilar Luna, Maryla Maliszewska. 2023. "Linking Trade to Jobs, Incomes, and Activities : New Stylized Facts for Low- and Middle-Income Countries." World Bank Policy Research Working Paper No. 10635, World Bank, Washington, DC.

World Bank Group. 2024. Poland Country Climate and Development Report. CCDR Series. November, 2024. The World Bank: Washington, DC.

World Bank. 2020. World Development Report 2020: Trading for Development in the Age of Global Value Chains. Report. The World Bank: Washington, DC.

World Bank. 2023. Country Climate and Development Report for Romania. CCDR Series. October, 2023. The World Bank: Washington, DC.

World Bank. 2024. Energizing Europe: Rising to the Challenge (Part 2). EU Regular Economic Report; No.9. The World Bank: Washington, DC.

World Bank. 2024. State and Trends of Carbon Pricing 2024. The World Bank: Washington, DC.

ANNEX A

# List of the EU NZIA net zero technologies

| Net-zero technologies | Sub-categories within net-zero technologies |
|---|---|
| Solar technologies | PV technologies |
| | Solar thermal electric technologies |
| | Solar thermal technologies |
| | Other solar technologies |
| Onshore wind and offshore renewable technologies | Onshore wind technologies |
| | Offshore renewable technologies |
| Battery and energy storage technologies | Battery technologies |
| | Energy storage technologies |
| Heat pumps and geothermal energy technologies | Heat pump technologies |
| | Geothermal energy technologies |
| Hydrogen technologies | Electrolyzers |
| | Hydrogen fuel cells |
| | Other hydrogen technologies |
| Sustainable biogas and biomethane technologies | Sustainable biogas technologies |
| | Sustainable bio-methane technologies |
| CCS technologies | Carbon capture technologies |
| | Carbon storage technologies |
| Electricity grid technologies | Electricity grid technologies |
| | Electric charging technologies for transport |
| | Technologies to digitalise the grid |
| | Other electricity grid technologies |
| Nuclear fission energy technologies | Nuclear fission energy technologies |
| | Nuclear fuel cycle technologies |
| Sustainable alternative fuels technologies | Sustainable alternative fuels technologies |
| Hydropower technologies | Hydropower technologies |
| Other renewable energy technologies | Osmotic energy technologies |
| | Ambient energy technologies, other than heat pumps |
| | Biomass technologies |
| | Landfill gas technologies |
| | Sewage treatment plant gas technologies |
| | Other renewable energy technologies |
| Energy system-related energy efficiency technologies | Energy system-related energy efficiency technologies |
| | Heat grid technologies |
| | Other energy system-related energy efficiency technologies |
| Renewable fuels of non-biological origin | Renewable fuels of non-biological origin technologies |
| Biotech climate and energy solutions | Biotech climate and energy solutions |
| Transformative industrial technologies for decarbonisation | Transformative industrial technologies for decarbonisation |
| $CO_2$ transport and utilisation technologies | $CO_2$ transport technologies |
| | $CO_2$ utilisation technologies |
| Wind and electric propulsion technologies for transport | Wind propulsion technologies |
| | Electric propulsion technologies |
| Other nuclear technologies | Other nuclear technologies |

ANNEX B

# Indicators across demand, supply, and ease of market access and their aggregation

We consider indicators across three dimensions of onshoring: demand, supply, and ease of market access:

## Demand

| # | Indicator Name | Data source |
|---|---|---|
| 1 | EU27's sectoral Foreign Input Reliance (FIR) from non-EU regions, 2020 | OECD |
| 2 | Share of non-EU regions in EU27's import, 2022 | CEPII BACI |
| 3 | Compounded Annual Growth Rate (CAGR) in exports of non-EU regions to EU27, 2017 – 2022 | CEPII BACI |
| 4 | EU27's use of local content in consumption of energy in each value chain, 2023 | EU Commission |
| 5 | EU27's 2030 target for use of EU content in consumption of energy from each value chain5 | EU Commission |
| 6 | Tariff-equivalent measures of CBAM's impact on export of affected products from non-EU regions | World Bank |
| 7 | EU27's spending on each value chain, 2017 – 2021 | IEA Renewables |
| 8 | EU27's manufacturing gap of technology for each value chain, 2030 relative to 2022 | EU Commission |
| 9 | EU27's product-level imports, 2022 | CEPII BACI |
| 10 | Cumulative FDI from other EU27 countries to each CEE country's value chain | FT Times fDI markets |

## Supply

| # | Indicator Name | Data source |
|---|---|---|
| 11 | Market share of CEE country-product in EU27's imports, 2022 | CEPII BACI |
| 12 | Export unit price of CEE country-product, 20222 | CEPII BACI |
| 13 | CAGR in exports of CEE country-product to EU23, 2018 – 2022 | CEPII BACI |
| 14 | CEE country's productive capabilities around a product, 20217 | CEPII BACI |
| 15 | CEE country's ease of transitioning into a new product (Method: XG Boost), 20218 | CEPII BACI |
| 16 | CEE country's domestic capacity addition in each value chain, 2017 – 22 | IEA Renewables |

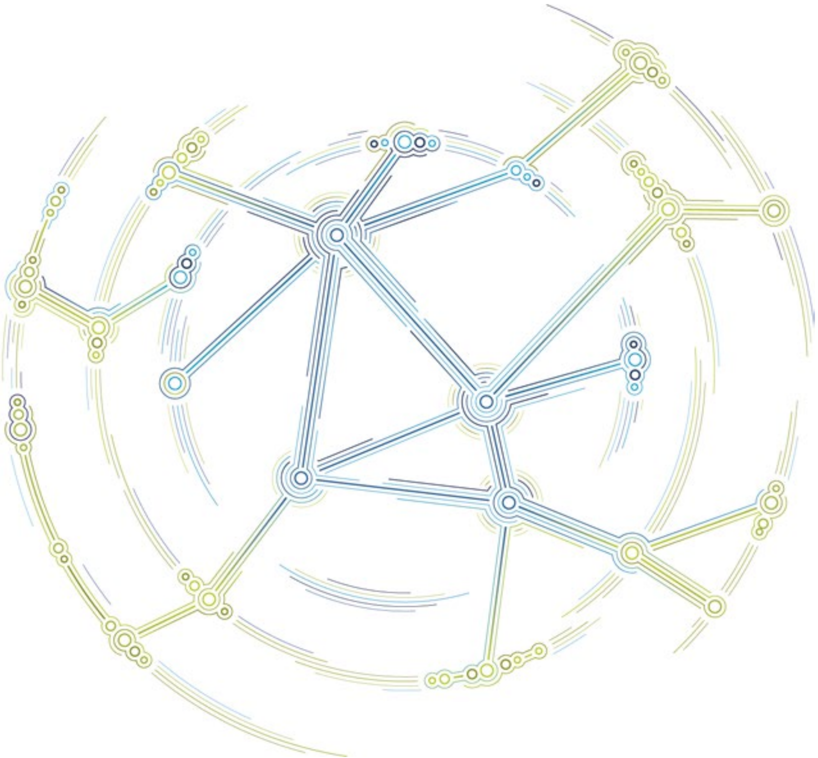
## Ease of Market Access

| # | Indicator Name | Data source |
|---|---|---|
| 17 | Bilateral logistics index between CEE countries and EU27 countries | World Bank |
| 18 | Travel time from CEE capitals to EU27 production/sales sites | Bruegel and Google Maps |

We employ Principal Component Analysis (PCA) to summarize the 18 variables into a composite index of Onshoring Attractiveness Score (OAS). This composite index weights each indicator by its share of variance in the total variance of selected components.[10] In doing so, we define the scope of the onshoring potential in two ways:

1. The intensive margin is related to existing product(ion) in each CEE country;
2. The extensive margin is related to new product(ion) in each CEE country.

As a result, for each CEE exporter-HS 6-digit product and EU27 destination, we obtain a single OAS. For ease of interpretation, we classify these OAS into three groups Low, Medium and High, using K-means clustering, one of the well-known unsupervised machine learning algorithms. This helps us find patterns in our data and infer groups with as few assumptions as possible. We define onshoring potential as observations with High OAS — across intensive and extensive margin.



WORLD BANK GROUP