Forum Energii | INDUSTRY

Clean technologies. A competitive Poland

Directions for the development
of domestic industry
by 2030

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The mission of Forum Energii is to initiate dialogue on public policy changes with key stakeholders, propose evidence-based solutions, and inspire action towards a fair and effective energy transition leading to climate neutrality.

We analyse developments in Poland as well as European and global trends in the energy sector and their implications for Poland. We pursue these objectives through publications, including reports, analyses and commentaries, as well as through expert workshops and debates. In this way, we create space for informed discussion on the most complex challenges associated with the energy transition and the transformation of key sectors of the economy.

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1.
Key findings

- The energy transition can become an important stimulus of industrial development in Poland. Growing demand for clean technologies represents not only a cost of adjustment but also an opportunity to retain a larger share of value added within the domestic economy. Poland has a substantial industrial base, strong engineering capabilities and companies that already operate within European supply chains. Across the sectors analysed in this report, Polish exports increased from EUR 25.9 billion in 2019 to EUR 47.2 billion in 2024.

- Poland is not starting from scratch. Several sectors already have well-established industrial specialisations, including rail, grids and transformers, selected segments of electromobility, heating systems, the circular economy and parts of the energy storage value chain. These are not merely footholds but industries and companies capable of growing alongside demand for clean technologies. Companies with Polish ownership account for 64.4% of sector revenues in the circular economy, 57.9% in rail, and 54.6% in grids and transformers.

- It is not necessary to build everything domestically; it is more important to choose carefully what should be developed. The analysis of 388 products across ten industries shows that achieving full domestic control of entire value chains is unrealistic in many technologies by 2030. The greatest opportunities lie in those segments where Poland already possesses expertise, production capacity, supplier networks or the ability to move quickly into more advanced market segments.

- Local content should mean more than assembly operations located in Poland. The greatest economic benefits arise when knowledge, intellectual property, design capabilities, systems integration, maintenance services and implementation expertise remain in the country. The location of production alone is not sufficient if key components, margins and technological decisions remain abroad. This is particularly evident in energy storage and electromobility, where companies with Polish ownership generate only 1.8% and 6.5% of sector revenues respectively, despite the high value of exports.

- Foreign investment can strengthen Polish industry if it is properly targeted. The presence of global companies creates jobs, provides access to markets and supports the development of local suppliers. Public policy should therefore encourage investments that create long-term capabilities in Poland, cooperate with domestic research and manufacturing ecosystems, and increase the participation of Polish firms in supply chains.

- The greatest risk is the fragmentation of efforts. Poland should concentrate support in areas where three conditions are met simultaneously: rapid market growth, an existing industrial base and a realistic opportunity to expand domestic participation in value creation. Otherwise, the energy transition will increase demand for technologies while most industrial benefits are captured by foreign suppliers.

- The state has instruments that can translate demand into industrial advantages. Stable regulations, predictable support schemes, well-designed public procurement, financing for research and development, support for certification processes and export promotion are all essential. A well-designed industrial policy should strengthen competition rather than protect companies from market pressure.

- Clean technologies are also a matter of security. Dependence on imported fossil fuels will gradually decline, but it may be replaced by dependence on imported equipment, components, raw materials and software. For this reason, the development of domestic capabilities in clean technologies should be treated as an element of Poland’s economic and technological security.

2.
Introduction

Industry in Poland and across the European Union is under considerable pressure. Growing global competition, high energy prices and supply chain dependencies on producers from outside the EU are forcing policymakers to develop a new industrial strategy. The European Commission has proposed the Clean Industrial Deal,[1] and, within its framework, the Industrial Accelerator Act.[2] The objective is to strengthen European demand for clean technologies and provide Member States with tools to build their own industrial advantages, often based on innovative solutions. Poland needs to identify these niches and treat their development as a strategic priority.

In the fields of energy and climate policy, the challenges are not limited to reducing dependence on fossil fuel imports and cutting emissions. They also include keeping energy prices under control. According to the National Energy and Climate Plan (*Krajowy Plan w dziedzinie Energii i Klimatu* – KPEiK), investments related to the energy transition are expected to reach PLN 2.7–3.5 trillion by 2040.[3] It is therefore important that as much of this spending as possible remains in Poland and supports the creation of modern jobs and strategic supply chains. This is achievable because Poland has one of the largest industrial bases in the European Union.

Industry currently accounts for 21–23% of Poland's GDP.[4] While the size of the industrial base alone does not guarantee success, it provides a strong starting point. This potential can be directed towards the development of clean and competitive technologies (cleantech).

Decarbonisation is becoming a strategic economic project, and Poland has a strong opportunity to benefit from this process. However, this requires a clear understanding of the country's strengths and a well-designed strategy for using them in global markets.

In this report, Forum Energii, in cooperation with the analytical centre SpotData, identifies those cleantech segments that could become Polish industrial and export specialisations by 2030.

Context

A domestic market develops on the basis of stable and substantial demand for new technologies and equipment, creating predictable conditions for investment. In the case of clean technologies, it is difficult to identify a coherent state strategy capable of strengthening such demand. The politicisation of energy policy, inconsistently designed support schemes and the expansionary industrial strategies of countries such as China have resulted in Poland importing most key energy technologies today. Even when production is located domestically, it is often limited to assembly operations, while key components continue to be imported.

This challenge is not unique to Poland. Much of the European Union faces a similar situation. It stems from the functioning of open markets, where lower prices tend to prevail, as well as from the deliberate industrial policies pursued by third countries. Through subsidies, economies of scale and cost advantages, these countries increasingly displace European producers from important market segments. If a technology is not critical and supplies can be diversified relatively easily, import intensity does not necessarily constitute a strategic risk.

1 European Commission, *Clean Industrial Deal. A plan for EU competitiveness and decarbonisation*, 2025.
2 European Commission, *Commission proposes new measures to boost EU industry and jobs*, 2026.
3 Ministry of Climate and Environment, *Draft National Energy and Climate Plan until 2030 with an Outlook to 2040,* 2025.
4 Industry is defined as Sections B (Mining and Quarrying), C (Manufacturing), and E (Water Supply; Sewerage, Waste Management and Remediation Activities). Source: Eurostat, database: nama_10_a64.

The problem arises when technologies are difficult to substitute, such as large power transformers, high-voltage cables or battery cells, where shortages can directly slow down the pace of the energy transition. An active industrial policy in the cleantech sector can strengthen national security and economic sovereignty while improving industrial competitiveness. However, this requires public authorities and companies to act proactively, including by:

- identifying areas of competitive advantage,
- creating stable demand through long-term strategies and investment mechanisms,
- providing targeted support through a diverse set of public policy instruments.

An old dilemma and new challenges – the role of the state in industrial policy

In an environment of growing geopolitical rivalry and an accelerating energy transition, Poland cannot afford to remain passive in the field of industrial policy. The debate over whether governments should actively shape economic development has effectively been settled. Today, all major economies pursue industrial policies to varying degrees. The question is therefore not whether public intervention is necessary, but how it should be designed in the field of clean technologies so that it remains effective, competitive and resistant to political pressures.

In this context, the cleantech sector has strategic importance. It is one of the foundations of energy security and of achieving national climate objectives. Technologies such as renewable energy, energy storage, hydrogen production and digital solutions for the energy system form the basis of new value chains. The absence of an active strategy would effectively mean dependence on technologies developed and manufactured outside Europe, creating a new source of vulnerability for European security.

The state already plays an important role in shaping demand through regulation, public procurement, support schemes and investment decisions. Strategic documents such as the National Energy and Climate Plan (Krajowy Plan w dziedzinie Energii i Klimatu – KPEiK) set the direction of the transition. The next step is the implementation of appropriate regulations and market frameworks, including procurement policies, support mechanisms and remuneration systems. These measures determine whether demand can be scaled effectively.

Another important element is innovation policy, which should facilitate the development of strategic niches and support inventions capable of meeting real market needs. Stable regulatory frameworks, public procurement and investment support instruments provide the predictable market signals needed for private companies to take technological risks. At the same time, maintaining competition and avoiding the long-term privileging of specific market participants remain essential conditions for success.

Innovation support should be linked to clearly defined public objectives, such as decarbonisation, security of supply and the development of technological capabilities, rather than the protection of existing market structures. The opposite of a modern industrial policy is the long-term support provided to coal mining. The sector neither creates new technological advantages nor develops export specialisations, yet it continues to absorb substantial public resources that could otherwise support activities with greater growth potential. Instead of planning and managing the transition in a rational way and gradually redirecting the energy sector towards new technologies, Poland continues to devote significant resources to supporting outdated solutions in pursuit of narrowly defined political objectives.

In summary, a deliberate and well-designed industrial policy in the cleantech sector has become a prerequisite for maintaining competitiveness, ensuring security and achieving the European Union’s climate objectives. The absence of a strategy does not mean neutrality. It means leaving the field open to other economies that are actively shaping future technology markets.

3.
Objectives of the report

The main objective of this report is to provide a concise, data-driven assessment of the development potential of selected segments of Poland's clean technology (cleantech) industry by 2030. The analysis identifies those areas of the value chain where Poland can build lasting competitive advantages and increase the share of local content. This is particularly relevant in the context of the European debate on the Industrial Accelerator Act (Akcelerator Przemysłowy), which is intended to strengthen demand for low-emission products manufactured in Europe, as well as the domestic discussion on local content.

The report has six specific objectives:

1. **Identifying key technological areas** – identifying those segments in which Poland already has competitive advantages or can realistically develop them, and determining the most promising parts of the value chain.
2. **Assessing the potential for local content development** – analysis of the share of companies with Polish ownership in sector revenues, their role in value chains, and the distinction between simple assembly activities and the genuine development of technological capabilities.
3. **Assessing Poland's position within the European Union** – evaluation of export specialisation, import intensity and the position of Polish firms within European supply chains.
4. **Identifying barriers and constraints to development** – financial, resource-related, regulatory, skills-related and technological barriers, including those areas where the creation of complete domestic production capabilities by 2030 should not be assumed due to the scale of investment required, technological barriers, resource constraints or the dominance of global suppliers.
5. **Identifying high-value-added development niches** – particularly in systems integration, electronics, automation, recycling, advanced components and implementation services.
6. **Formulating recommendations for industrial policy** – regarding investment support, research and development (R&D), exports, public procurement and regulatory stability, with the objective of strengthening technological capabilities and economic resilience.

How do we define clean technologies?

For the purposes of this report, clean technologies are defined broadly as solutions that increase the use of renewable resources, enable emissions reductions, improve energy efficiency or support the electrification of the economy. They include energy, industrial and transport technologies, together with their raw-material and digital ecosystems.

Under this approach, cleantech is not simply a catalogue of end-use products, but an entire value-chain ecosystem encompassing raw materials and components, systems integration, final products and implementation services.

The technological scope of the report covers ten segments:

1) energy storage,
2) wind energy,
3) photovoltaics,
4) electromobility,
5) rail,
6) heating systems,
7) grids and transformers,
8) circular economy and material recovery,
9) critical raw materials,
10) industrial low-emission technologies.

How do we define local content?

In public debate, local content is generally defined in two ways:

- broadly – as any production taking place in Poland,
- narrowly – as production carried out by companies with predominantly Polish ownership.

In this report, primary emphasis is placed on the narrower definition by focusing on the share of companies controlled by domestic owners. However, the broader perspective is also considered because of the benefits associated with foreign investment, including the creation of jobs and supply chains. Manufacturing activities carried out in Poland by foreign-owned companies are therefore analysed separately from Polish local content.

In March 2026, the Ministry of State Assets (Ministerstwo Aktywów Państwowych) presented an official definition of local content. According to this definition, local content is the value of goods produced or services provided by a domestic entity. Domestic firms are defined as companies with predominantly Polish ownership.

Criteria used to assess the “Polish character” of a company:

- 25% weighting – beneficial owner based in Poland,
- 25% weighting – principal business activity carried out in Poland,
- 15% weighting – tax residence in Poland,
- 15% weighting – more than 50% of employees pay taxes and social security contributions in Poland,
- 10% weighting – registered office in Poland (National Court Register / Central Registration and Information on Business) and uninterrupted operation for at least three years,
- 10% weighting – more than 50% of annual turnover generated in Poland.

4.
Methodology

To conduct the analysis in a systematic manner, the following steps were undertaken:

1. Analysis of the largest clean technology sectors, including an assessment of their market potential and the share of local content based on public statistics.
2. In-depth interviews with leading experts representing individual sectors.
3. Examination of each strategically important segment to identify those parts of the supply chain where Poland already has strong specialisations and those where capabilities are still being developed.
4. Distinguishing between cases where strong performance is driven by companies with Polish ownership and those where production in Poland is primarily carried out by foreign-owned firms.
5. Based on these findings, and taking into account product characteristics and company profiles, recommendations regarding appropriate support instruments were developed. Their relevance was subsequently verified through consultations with industry experts.

The product-level analysis covers 388 cleantech products identified using eight-digit CN/PRODCOM commodity codes. Production data for the European Union were obtained from PRODCOM, trade data from Eurostat Comext, and revenue and profitability data from Monitor Firm and the National Official Business Register (REGON – Rejestr Gospodarki Narodowej). For the purposes of the product analysis, each commodity code was assigned to a single primary sector. Categories overlap only in the supply-chain analysis, where the same components may serve as a common industrial base for several sectors.

The sectoral analysis covers exports, production, the ratio of imports to consumption, and the trade balance, while the financial analysis draws on company revenue, revenue growth and net profitability data.

Key definitions:

- **The RCA (Revealed Comparative Advantage) indicator** measures a revealed comparative advantage. It shows whether the share of a given product in Poland's exports is higher than the average share observed across the European Union. A value above 1 indicates export specialisation.
- **Import intensity** – in this report, import intensity is defined as the ratio of imports to consumption, measuring the share of demand met through imports. Whenever imports or import intensity are discussed, these terms refer to total imports from all sources, including imports from other EU Member States.
- **Supply chain** – sequence of activities leading to the production of a final product. Individual segments of the supply chain differ in terms of their role, value added and technological complexity.

Figure 1. Three tiers of the supply chain

COMPLEXITY LEVEL →

TIER 3	TIER 2	TIER 1
Material inputs (upstream)	**Components and technologies** (midstream)	**Final products** (downstream)
Processed raw materials, construction materials and chemical feedstocks forming the industrial base	Key components, spare parts, control systems, and advanced intermediate products essential for the operation of the final product	Finished equipment, complete systems and vehicles delivered directly to end users, investors or the power system
Examples		
• silicon electrical steel, • aluminium, • graphite, • carbonates and industrial chemicals	• Battery separators, • inverters and converters, • steering systems, • turbine blades	• Electric buses, • heat pumps, • electric multiple units (trains), • wind turbines

Source: SpotData.

5.
The specific nature of the clean technology market and its relevance to Poland

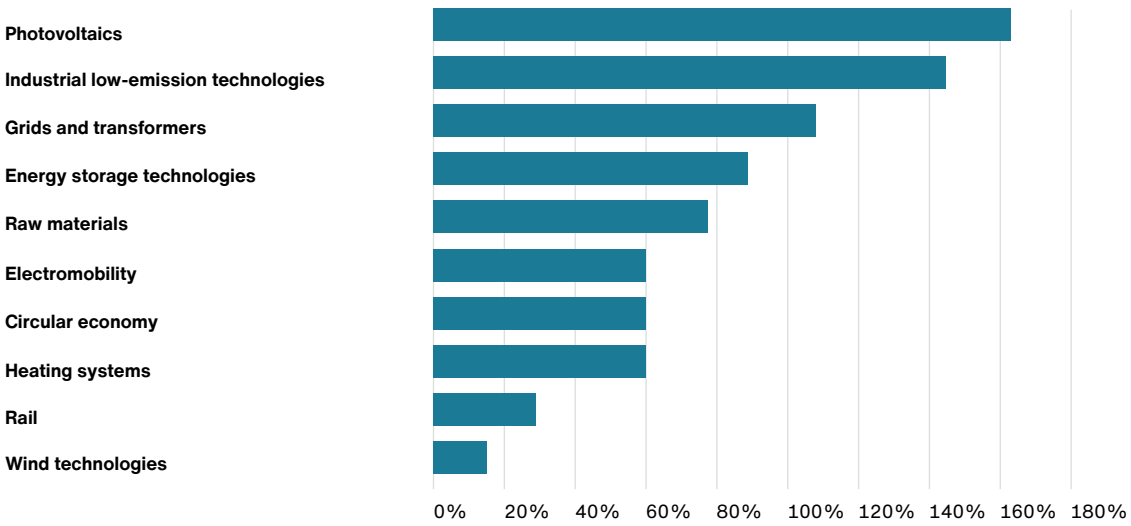
The EU energy transition relies heavily on imports

Global demand for clean technology equipment is growing rapidly, but European manufacturers are capturing an increasingly smaller share of this market. Their production capacity is not expanding quickly enough to meet demand. Without sufficient scale, price competition increasingly favours producers located outside Europe. As a result, European manufacturers face growing competitive pressure.

The most striking example is photovoltaics, where import intensity, measured as the ratio of imports to consumption, reached 163% in 2024. High dependence on external suppliers is also evident in industrial low-emission technologies (145%), grids and transformers (107%), energy storage technologies (88%) and raw materials (77%). By contrast, wind technologies and rail perform relatively well, with most demand being met through production within the European Union.

Conclusion: policy efforts should focus on those segments of the supply chain where Europe has a realistic opportunity to compete.

Chart 1. Import intensity of cleantech sectors in the EU (2024)



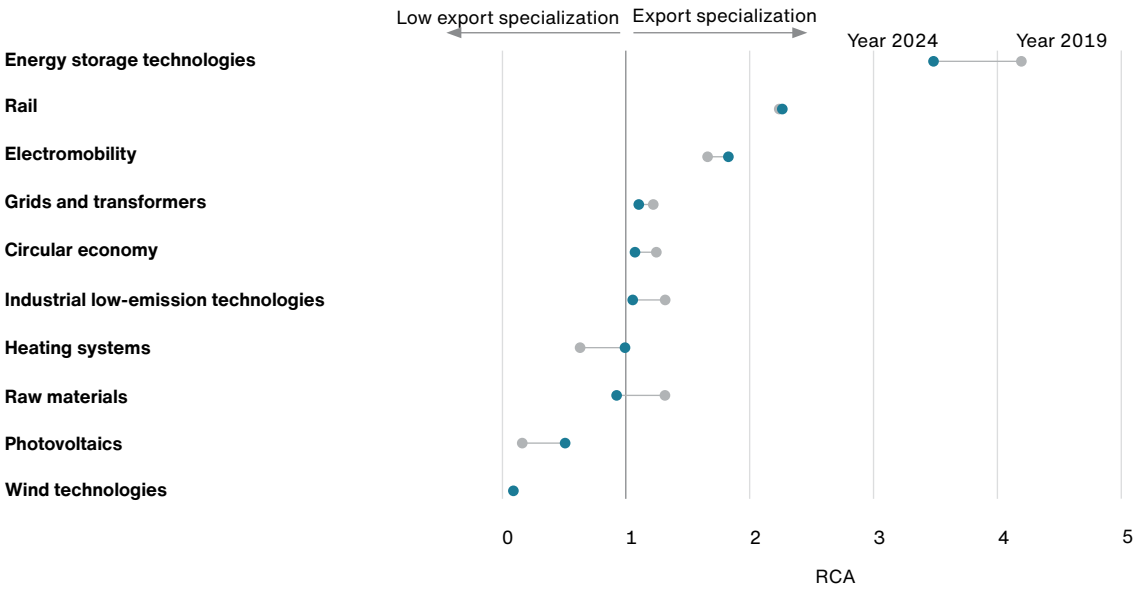
Source: SpotData.

Poland has few strong cleantech specialisations, although some sectors have strong players

Rail performs best in this category, combining a strong export position with a substantial share of Polish-owned capital and a well-developed supply chain. In energy storage technologies, Poland's high level of specialisation is driven primarily by a single large foreign investment, while in the remaining sectors competitive advantages are either limited or too weak to constitute a lasting specialisation.

Conclusion: the ability to identify the right supply chains and support the development of critical niches is a key task of industrial policy.

Chart 2. Export specialisations within the EU



Source: SpotData.

How can Poland make the most of its potential?

Even without a complete supply chain, Poland has several product categories with strong specialisations. These include products that already contribute to decarbonisation today, such as lithium-ion batteries, electric multiple units, distribution transformers and heat pumps. There are also industrial sectors that are not cleantech technologies sensu stricto (e.g. trucks and gas boilers), but which can provide the capabilities needed to transition towards low-emission solutions. This concerns the ability to leverage existing production capacity, know-how, engineering expertise and supplier networks for the development of technologies such as electric vehicles and heat pumps.

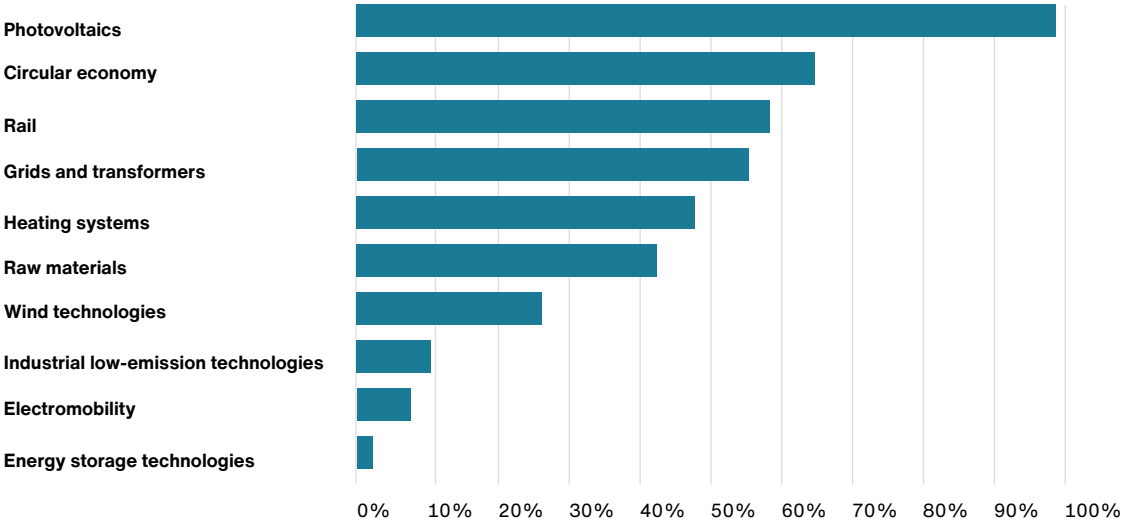
Conclusion: the key challenge is the ability to transform industrial processes and move into more promising areas while making the best possible use of existing resources – physical capital, knowledge and experience.

Only some export successes are associated with products made by companies with Polish capital

The presence of foreign companies can bring important benefits, including knowledge transfer and the development of local supplier networks. However, the greatest long-term benefits come from the ability to commercialise domestic technologies. Cleantech sectors differ significantly in the share of companies with domestic capital and in their ownership structures. In energy storage technologies and electromobility, companies with Polish capital play only a marginal role, whereas in rail and in grids and transformers they already account for a significant share of revenues and operate not only as contractors performing simple tasks, but also as manufacturers of complex equipment and systems integrators.

Conclusion: careful consideration should be given to which sectors deserve support. In other cases, efforts should focus on developing specific niches.

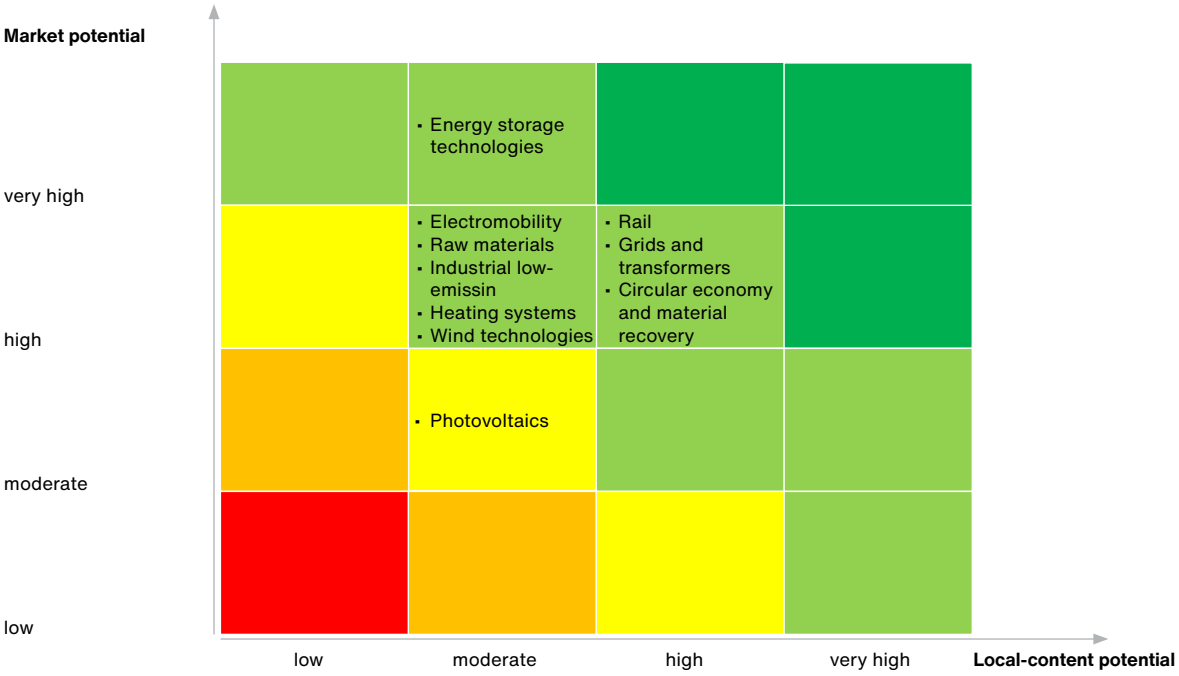
Chart 3. Share of revenues generated by companies with domestic capital



Source: SpotData.

Taking into account the characteristics of Poland's industrial base and the direction of the energy transition, Poland has the potential to develop technological and market niches in as many as **ten cleantech sectors** by 2030. However, these sectors differ significantly in terms of market growth, the current position of Polish firms and the potential to capture a larger share of value added. In only three sectors[5] does Polish capital already play a significant role. Consequently, the majority of public policy efforts should focus on supporting local content in those sectors where demand is expected to grow most rapidly while the current participation of Polish firms in supply chains remains limited.

Chart 4. Development potential of clean technologies in Poland*



* Chart 4 presents the approximate position of cleantech sectors from the perspective of industrial policy. It compares market growth with the current strength of domestic firms and the potential for increasing local content. It does not assess the importance of individual technologies for the energy transition, nor does it reflect the scale of future investment requirements. Increasing both market potential and local content requires that a given sector be recognised as a priority by the government and supported by a regulatory framework that enables its development.
Source: SpotData.

5 Excluding photovoltaics due to its very high dependence on imported modules.

Analysis of the potential of Poland's key clean technologies

The following chapters examine the clean technologies considered most important for Poland. For each technology, the report identifies key niches, existing specialisations and the main barriers to development.

The assessment takes into account:

- its role in Poland's energy transition,
- market growth potential,
- consistency with EU strategies,
- supply chains,
- local content.

6.
Energy storage technologies

Role in the energy transition: electricity storage is a key prerequisite for integrating a growing share of renewable energy sources into the power system by increasing its flexibility. The development of this segment strengthens competitiveness in power electronics, systems integration and software, while simultaneously improving system security and reducing balancing costs.

Market outlook: approximately 21% annual growth globally (BNEF).[6] Demand will be driven by the integration of renewable energy sources, the development of residential energy storage systems and the need to increase the flexibility of the power system.

Position of the EU: critical dependence on imports from Asia remains one of the main characteristics of the EU market. At the same time, the market itself is growing rapidly – between 2019 and 2024, the value of production in the EU increased from EUR 5.9 billion to EUR 17.5 billion. Import intensity, measured as the ratio of imports to consumption, reached 88.1% in 2024, demonstrating that EU demand is still largely met through external supplies.

EU strategy:

- batteries have been recognised as a priority under the Net-Zero Industry Act (NZIA),[7]
- critical raw materials for batteries are covered by the Critical Raw Materials Act (CRMA),[8]
- the battery market framework is defined by the Battery Regulation;[9] previous initiatives included the establishment of the European Battery Alliance in 2017,[10] the adoption of the Strategic Action Plan on Batteries in 2018,[11] and the approval by the European Commission of two Important Projects of Common European Interest (IPCEI) in the battery value chain in 2019 and 2021.

Position of Poland: third-largest battery exporter in the world in 2024[12] and highly competitive within the EU market, although new players are emerging. Between 2019 and 2024, the value of Polish exports increased from EUR 3.0 billion to EUR 7.4 billion, while the RCA indicator for the sector reached 3.50.

Local content: low in volume terms, with footholds being established in niche areas; domestic firms exhibit significantly weaker financial indicators, which hampers reinvestment.

6 N. Nsitem, *Global Energy Storage Market Records Biggest Jump Yet*, BloombergNEF, 2024.
7 *Regulation (EU) 2024/1735 of the European Parliament and of the Council of 13 June 2024 establishing a framework of measures for strengthening Europe's net-zero technology manufacturing ecosystem and amending Regulation (EU) 2018/1724.*
8 *Regulation (EU) 2024/1252 of the European Parliament and of the Council of 11 April 2024 establishing a framework for ensuring a secure and sustainable supply of critical raw materials and amending Regulations (EU) No 168/2013, (EU) 2018/858, (EU) 2018/1724 and (EU) 2019/1020.*
9 *Regulation (EU) 2023/1542 of the European Parliament and of the Council of 12 July 2023 concerning batteries and waste batteries, amending Directive 2008/98/EC and Regulation (EU) 2019/1020, and repealing Directive 2006/66/EC.*
10 Annex 2. *Strategic Action Plan on Batteries to the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Europe on the Move. Sustainable Mobility for Europe: Safe, Connected and Clean* (COM(2018) 293, 17 May 2018).
11 European Commission, *In focus: Batteries – a key enabler of a low-carbon economy*, 2021.
12 According to data from Eurostat Comext and UN Comtrade Database.

Table 1. Characteristics of Polish-owned and foreign-owned firms

Characteristic	Polish-owned firms	Foreign-owned firms
Share of revenues	1.8%	98.2%
Revenue growth (2018–2023)	5.5%	1003.0%
Net profitability	1.2%	4.1%
Number of patents (2001–2025)	20	2

Source: SpotData.

Supply chain structure:

- **Raw material extraction and processing:** refining of lithium, cobalt, nickel and graphite. This stage is highly dependent on access to deposits and geopolitical developments. The first investments are emerging in Poland, but the segment remains dominated by foreign companies.
- **Component manufacturing:** production of advanced active materials (cathodes and anodes) and separators. This is a high-tech process requiring highly precise engineering. In Poland, this stage is heavily dominated by foreign capital, primarily Korean, although the influence of Chinese companies is also growing as they manufacture key components for global players.
- **Cell integration into complete systems:** the most important stage in terms of value added and system integration. The process requires very large capital investments and access to patented battery chemistry technologies. In Poland, it is entirely monopolised by a foreign company, which has made the country a battery export powerhouse built on fragile foundations.
- **Battery pack assembly:** the integration of cells into complete power systems equipped with battery management systems (BMS) and cooling systems. A single player dominates the passenger car battery segment. Polish-owned firms specialise in more demanding, low-volume applications, such as buses and stationary storage systems.
- **Recycling:** closing the loop through the recovery of valuable metals (urban mining). Owing to EU regulations requiring the use of secondary raw materials, this is the fastest-growing niche for domestic firms. This part of the supply chain includes many companies with Polish ownership.

Table 2. Revealed comparative advantage indicators by value-chain element

Value-chain element	Product name	RCA
Final product	Lithium-ion batteries	5.01
Final product	Industrial/traction batteries (liquid electrolyte)	3.91
Final product	Other electric batteries (not elsewhere classified)	3.53
Final product	Starter batteries (AGM/gel/sealed)	3.16
Final product	Ni-MH (nickel-metal hydride) batteries	2.17
Final product	Starter batteries (conventional flooded)	1.27
Final product	Industrial/other batteries (AGM/gel/sealed)	1.26
Component	Battery separators	24.95
Component	Battery parts (casings, cells)	1.16
Component	Primary cell parts	0.16
Raw material	Synthetic graphite	1.04
Raw material	Nickel sulphates	0.73
Raw material	Lithium hydroxide	0.50
Raw material	Nickel oxides	0.32
Raw material	Lithium carbonates	0.02

Source: SpotData.

Barriers to the development of local content:

- **Capital barrier:** the disparity in scale of operations. High margins and exponential revenue growth among foreign firms enable continuous reinvestment in lithium-ion battery production lines, widening the gap between them and Polish competitors.
- **Technological barrier:** the lack of expertise in battery chemistry forces domestic firms to assume the role of integrators, assembling systems from ready-made cells.
- **Raw-material barrier:** without domestic mines, raw-material security depends on imports and, in the longer term, potentially on the effectiveness of recycling.

Development niches:

- **Assembly of specialised battery systems** – while the passenger-car battery market is already saturated, Polish-owned firms perform very well in the segments of electric buses, trolleybuses and industrial machinery. Smaller players benefit from their flexibility, allowing them to design battery packs tailored to specific customer requirements. Poland can develop niches in the production and sale of solutions for a wider range of vehicles that are also undergoing decarbonisation.
- **Supercapacitors for data centres** – these technologies stabilise the operation of data centres during sudden spikes in computing demand, including those associated with artificial intelligence. Unlike traditional batteries, supercapacitors operate on a microsecond timescale. By attracting technologies such as graphene-based supercapacitors, Poland has the potential to become a manufacturing hub for this critical digital infrastructure.
- **Advanced chemistry and materials science** – Polish engineering expertise in battery chemistry and materials science (the pre-CTC stage) is regarded as world-class. The main challenge is converting this scientific potential into commercially viable products.

Beyond reach by 2030:

- **Raw-material base –** without domestic mines, Poland will remain dependent on imports. Improvements in raw-material security will require the expansion of recycling capacity, although this alone will not be sufficient to fully meet demand.

Recommendations for public policy:

1. **Concentrate support on high-margin niches**
   Rather than subsidising competition in the passenger-car battery market, public funding and research and development (R&D) grants should be directed towards companies developing battery systems for public transport, heavy-duty transport and stationary energy storage systems (ESS), where Polish-owned firms already have established footholds.

2. **Prioritise recycling**
   Battery recycling should be recognised as a strategic industry. Tax incentives and fast-track permitting procedures for metal recovery facilities developed by Polish firms are essential. This would strengthen raw-material security and retain more value added within the domestic economy.

3. **Establish strategic partnerships where entry barriers are too high**
   In sectors such as energy storage, where battery chemistry technologies and access to critical materials create substantial barriers for Polish firms, the preferred approach should be the formation of intelligent partnerships (joint ventures) rather than attempts to build capabilities entirely from scratch. Poland does not possess critical raw materials or patents related to battery chemistry, but it does have important advantages, including its geographic location, access to the EU market and a highly qualified engineering workforce. These strengths should be leveraged in negotiations with technology partners.

4. **Create joint ventures that safeguard Poland's economic interests:**

   - **careful selection of value-chain stages –** Polish firms entering partnerships with global cell manufacturers should contribute expertise in system integration, battery pack assembly, battery management systems (BMS) and cooling systems. High margins are generated at the stage of adapting cells to specific applications, and Polish firms already possess competitive strengths in this area,
   - **second-life and recycling conditionality** – both government and industry should seek contractual provisions ensuring that batteries manufactured in Poland are also processed in Poland at the end of their useful life. This would enable domestic recycling firms to retain access to valuable black mass and strengthen raw-material sovereignty without the need for domestic mining,
   - **location of applied R&D activities** – public support for strategic partnerships should be conditional on the establishment of engineering centres in Poland that adapt global technologies to the specific requirements of European electricity networks (grid codes). This is a niche in which Polish engineers possess significant competitive advantages.

7.
Wind technologies

Role in the energy transition: wind power (including offshore wind) is one of the main pillars of power-sector decarbonisation and increasing domestic electricity generation without the use of fossil fuels. The development of this segment also improves the country's energy security. Challenges to stable demand include the high degree of politicisation surrounding the sector and regulatory unpredictability, particularly with regard to the Distance Act[13], and subsequent conflicting signals concerning amendments to this legislation.

Market outlook: the EU wind energy market is expected to grow by approximately 7% annually until 2030.[14] In Poland, additional demand will be generated by offshore projects in the Baltic Sea and the expansion of onshore wind power, provided that regulatory and administrative barriers are effectively reduced. In recent years, Europe has faced a slowdown in wind energy development due to grid constraints and permitting delays. However, offshore wind projects in the Polish Baltic Sea guarantee domestic demand in the coming years. The technological maturity of the sector means that innovation is generally incremental rather than disruptive.

Position of the EU: wind technologies represent one of Europe's core technological strengths and are actively protected by the EU against growing international competition. In recent years, the industry has faced challenges such as supply-chain disruptions, high interest rates and the suspension of advanced projects. Most orders are fulfilled within the European Union, including final products. Between 2019 and 2024, the value of EU production increased from EUR 9.8 billion to EUR 10.2 billion, while import intensity, measured as the ratio of imports to consumption, stood at 14.9% in 2024.

EU strategy: wind technologies, particularly offshore wind, are treated as a priority under the Net-Zero Industry Act (NZIA).[15] They are also covered by the European Wind Power Package.[16] Supporting documents emphasise strengthening Europe's industrial base and increasing the resilience of supply chains.

Position of Poland: Poland is still in the process of building its position in the sector and currently lacks complete domestic products. Wind technologies have developed below their potential to date. Poland is in the early stages of offshore wind development and continues to face legislative deadlock in onshore wind energy. Nevertheless, the country remains an attractive location for manufacturing facilities operated by foreign companies. Exports from the sector remain modest: in 2024 they amounted to approximately EUR 41 million, compared with EUR 38 million in 2019. The sector's RCA indicator stands at 0.11.

Local content: the market is dominated by foreign firms (approximately 80% of offshore supplies and around two-thirds of the value of onshore investments), although strong foundations exist for the successful integration of Polish companies into higher-value segments of the supply chain. Expanding production capacity and actively promoting local content will be critical for future development.

13 *Act of 20 May 2016 on Investments in Wind Power Plants.*
14 *WindEurope, Wind energy in Europe. 2024 Statistics and the outlook for 2025-2030,* 2025. WindEurope forecasts annual installations to increase from 16 GW in 2023 to 26 GW by 2030.
15 *Regulation (EU) 2024/1735 of the European Parliament and of the Council of 13 June 2024 establishing a framework of measures for strengthening Europe's net-zero technology manufacturing ecosystem and amending Regulation (EU) 2018/1724.*
16 *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: European Wind Power Action Plan* (COM(2023) 669, 24 October 2023) *and Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Delivering on the EU Offshore Renewable Energy Ambition* (COM(2023) 668, 24 October 2023).

Table 3. Characteristics of Polish-owned and foreign-owned firms

Characteristic	Polish-owned firms	Foreign-owned firms
Share of revenues	24.3%	75.7%
Revenue growth (2018–2023)	42.5%	8.2%
Net profitability	3.6%	4.3%
Number of patents (2001–2025)	7	2

Source: SpotData.

Supply chain structure:

Offshore wind is one of the most complex investment undertakings in the energy sector. Individual projects are worth tens of billions of zlotys and require the coordination of numerous suppliers and contractors. Against this background, onshore wind is less complex and less capital-intensive.

- **Foundation** – the base of the wind farm
  - **Offshore wind energy:** In this analysis, three types of foundations are distinguished: monopiles, jacket structures, gravity-based structures (GBS).[17] Monopiles are the least expensive solution but are dominated by European competitors. GBS foundations represent one of the main opportunities for Poland's offshore industry, particularly for shipbuilding and steel construction companies, in later stages of project development, primarily after 2030.
  - **Onshore wind energy:** large reinforced-concrete foundations dominate this segment. They are built entirely by domestic construction firms using exclusively local materials.

- **Turbines** – the highest value-added segment
  - **Offshore wind energy:** a turbine consists of a tower, nacelle, blades, rotor and internal mechanisms including gearboxes, generators, control systems, bearings, shafts and safety systems. Offshore turbines currently typically have capacities of 14–15 MW, although prototypes with capacities of 21.5 MW have already appeared. Complete turbine systems are manufactured exclusively by two European companies, while Chinese competitors are already testing models with capacities of 26 MW. Between the foundation and the turbine, yellow connecting elements known as transition pieces are installed. These components are manufactured in Poland.
  - **Onshore wind energy:** onshore wind turbines typically have capacities ranging from 2 MW to 7 MW and consist of a tower, nacelle, blades and mechanical and electrical systems. The production of complete turbines remains entirely in the hands of global manufacturers. However, the role of Polish firms producing components, including towers, steel structures and mechanical elements, is gradually increasing.

- **Cabling** – internal connections and grid integration
  - **Offshore wind energy:** each turbine must be connected by cables to an offshore transformer station, which then transmits electricity to shore through an export cable. The cable is routed through a dedicated tunnel constructed using horizontal directional drilling (HDD), an area in which Poland has developed a strong specialisation. Onshore, the electricity is transmitted to a transformer substation and then fed into the national power grid. Despite the presence of a strong domestic player in cabling, most cables continue to be imported.
  - **Onshore wind energy:** manufacturers of both high-voltage and low-voltage cables play an important role. Polish companies possess the required competencies in this field.

- **Services** – domestic capabilities are also developing in diagnostic, forecasting, installation and transport services. Polish firms play an important role in these activities due to their technical expertise and the local nature of many services.

17 In practice, other solutions such as suction buckets are also used; however, they are not included in this analysis due to the lack of comparable data.

Table 4. Revealed comparative advantage indicators by value-chain element

Value chain element	Product name	RCA
Final product	Wind turbine generator sets	0.03
Component	Flywheels and pulleys	2.98
Component	High-voltage cables > 1000V	2.25
Component	Transformer and coil parts	1.28
Component	Steel towers and masts	0.3
Raw material	Unwrought aluminium alloys	2.4
Raw material	Copper waste	0.9
Raw material	Glass fibres	0.11
Raw material	Carbon fibres	0.04

Source: SpotData.

Barriers to the development of local content:

Offshore wind energy:

- **lack of experience:** developers require experience in offshore projects or large-scale energy infrastructure, references from comparable projects, quality certifications and familiarity with international FIDIC standards. Even where technical capabilities are available, large foreign developers are often reluctant to entrust critical contracts to companies without a proven offshore track record,
- **insufficient bank guarantees:** due to the high capital intensity of projects, substantial bank guarantees are required, often exceeding the capabilities of smaller Polish companies,
- **lack of port space:** this prevents the storage, assembly, and servicing of components,
- **lack of a credible strategy:** government plans regarding the energy mix change over time, making it difficult for companies to plan financially and undertake investment risk.

Onshore wind energy:

- **opposition to further development:** the 2016 Wind Farm Investment Act effectively halted the development of new wind farms in Poland, except for projects that had already obtained location permits. Although the regulations were partially relaxed in 2023, market growth is still hindered by siting procedures, unclear regulations, and opposition from some local communities. Further regulatory reform is required to trigger a new wave of investment.

Development niches:

An analysis of the wind energy supply chain in Poland—both offshore and onshore—shows that these segments differ significantly in terms of entry barriers, capital requirements, and the readiness of Polish industry. This leads to a natural division into two stages:

- **phase one (5–10 years)** – focus on scaling market segments where Polish companies already possess competencies, contracts, and references,
- **phase two (10–20 years)** – Poland should support experimentation, research, and development across all technological areas involved in the investment supply chain.

The above distinction is important from the perspective of selecting industrial policy instruments. Different tools are effective for companies that need scale and access to contracts, while others are better suited to building capabilities from the ground up.

Phase one (5–10 years)

This phase concerns segments in which Polish industry already possesses proven manufacturing capabilities, international certifications and a growing order portfolio. Growth potential stems not from developing new capabilities, but from increasing production scale and expanding into export markets.

These include:

- **towers and steel structures (offshore and onshore)** – the main challenge is not technology, but the ability to compete for contracts in the German and Scandinavian market,
- **GBS concrete foundations (offshore)** – the key constraint is port infrastructure. Producing 100 foundations per year requires approximately 30 hectares of port space, which is currently unavailable in Poland,
- **reinforced concrete foundations (onshore)** – unlike offshore wind farms, the foundations for onshore wind farms are produced entirely by domestic construction companies using local materials. The share of Polish industry at this stage is close to 100% and requires no additional intervention – the segment is mature and stable,
- **transition pieces and mechanical components (offshore and onshore)** – these are segments in which Poland already possesses references and capabilities, with scale rather than technology representing the primary barrier,
- **medium- and high-voltage onshore cables (offshore and onshore)** – in the onshore segment, MV and HV cables are an established Polish specialisation. The segment does not require technological support but could benefit from larger order volumes,
- **maintenance, servicing and installation services (offshore and onshore)** – in onshore wind energy, installation and maintenance are almost entirely the domain of Polish companies, which service all turbine types operating in Poland. An increasing number of specialists are obtaining GWO certifications. In offshore wind energy, service bases are being developed in Łeba, Ustka and Władysławowo. This is a segment with relatively low barriers to entry but substantial long-term potential, as wind farms operate for 25–30 years and require continuous maintenance. With every newly commissioned wind farm, demand for maintenance services increases,
- **design and consultancy services (offshore and onshore)** – this is a segment in which competencies are difficult to replicate and stem from many years of experience. Polish companies conduct wind resource assessments, technical audits and energy production forecasts. In offshore wind energy, they additionally carry out geophysical, geotechnical and environmental surveys, drawing on their knowledge of the specific characteristics of the Baltic Sea. The Institute of Meteorology and Water Management – National Research Institute (Instytut Meteorologii i Gospodarki Wodnej – Państwowy Instytut Badawczy, IMGW-PIB) is developing tools for forecasting electricity generation from wind farms,
- **HDD drilling and earthworks (offshore)** – this is one of Poland's recognised specialisations in offshore wind energy.

Phase two (10–20 years)

This group includes segments in which Poland currently does not possess manufacturing capabilities, but where gradual capability development is possible. In most cases, the realistic pathway is technology transfer from foreign investors operating in Poland rather than building capabilities entirely from scratch:

- **Offshore cables (array cables and export cables)** – expanding into offshore cable production by existing manufacturers is technologically feasible, but requires 5–7 years of investment in R&D, new production lines, offshore testing and certification. For this reason, it is one of the segments where there is a genuine opportunity to make the leap from onshore to offshore capabilities, provided that targeted support is available through research programmes.
- **Medium- and high-power wind gearboxes (onshore and potentially offshore)** – development prospects exist, but the scale should be assessed realistically. There is a significant technological gap between a 5 MW onshore turbine and a 15 MW offshore machine, which cannot be bridged within a single decade.
- **Control systems, SCADA and diagnostics (offshore and onshore)** – Poland possesses systems integration capabilities (a large base of IT companies and R&D centres), but lacks manufacturing expertise in key components. The realistic development path is to enter the value chain through software and services rather than hardware. Consequently, technology transfer through strategic partnerships is more likely than development from scratch.

- **Electrical systems for offshore substations (offshore)** – Polish companies are capable of constructing the steel structures of offshore platforms. However, the electrical systems inside them—transformers, switchgear and power supply systems—remain the domain of large foreign-owned companies, despite being manufactured in Poland. Replacing global suppliers by 2030 is unlikely; a more realistic approach is to develop capabilities in subsystem integration and assembly.
- **Rotor blades** – maintenance and repair (offshore and onshore) – the production of offshore wind turbine blades remains beyond the reach of Polish-owned industry because Poland lacks expertise in the manufacture of large-scale composite materials. However, blade maintenance and repair services are available locally and can provide an entry point into this part of the value chain.

Beyond reach by 2030:

- **full substitution of imports with domestic production by Polish-owned firms** – complete wind turbines, large-scale rotor blades and complete electrical systems for offshore substations. Within such a short timeframe, technological advantages and economies of scale in these segments will remain with global companies.

Recommendations for public policy:

1. **Phase one – scaling existing capabilities**

- **Investment in port infrastructure** – the European Bank for Reconstruction and Development report,[18] based on an analysis of economic zones, indicates that the effectiveness of industrial policies depends on proximity to infrastructure (particularly ports) and the availability of skills. The installation port in Gdańsk and the development of ports in Świnoujście are prerequisites for the development of the domestic offshore supply chain, including the GBS foundation segment.
- **Credit guarantees and state-backed loans** – financial barriers represent a significant obstacle for medium-sized Polish companies. This is a challenge throughout the Polish supply chain: developers require high bank guarantees that exceed the capabilities of smaller suppliers. A guarantee programme operated by State Development Bank of Poland (Bank Gospodarstwa Krajowego) for offshore and onshore suppliers would have a low fiscal cost while directly reducing entry barriers. It is a moderately non-distortive instrument commonly used in countries with stronger administrative capacity.
- **Support for exports and international expansion of Polish firms** – the EBRD report identifies trade finance as one of the least distortive industrial policy instruments and one that incorporates a built-in market test: a company must win a contract abroad. Polish manufacturers of towers and steel structures already hold European certifications and are capable of competing for contracts in Germany and Scandinavia, where offshore capacity is expanding. Support instruments should include export loans guaranteed by BGK and Export Credit Insurance Corporation (Korporacja Ubezpieczeń Kredytów Eksportowych, KUKE), support for Polish firms investing in service facilities in ports located in target markets, and the systematic inclusion of suppliers in trade missions and industry fairs (WindEnergy Hamburg, Offshore Energy Amsterdam) organised by the Polish Investment and Trade Agency (Polska Agencja Inwestycji i Handlu, PAIH).
- **Point-based incentives in auctions (instead of local content requirements)** – the EBRD report, in its discussion of localisation requirements, indicates that strict local content requirements can increase production costs, limit access to the latest technologies and create excessive profits for firms supplying substandard products. The report therefore recommends incentives rather than requirements, combined with a clear definition of what constitutes local content and effective monitoring of implementation.
- **Support for certification and standardisation** – one of the main barriers faced by Polish firms is the requirement for offshore references and international certifications (FIDIC, GWO). Co-financing programmes for certification, modelled on instruments used in the Baltic states, could accelerate the integration of Polish firms into supply chains at minimal fiscal cost.

18 EBRD, *Transition Report 2024-25. Navigating industrial policy*, 2024.

2. Phase two – building new capabilities

- **Competitive R&D grants** – the EBRD report emphasises that grants are most effective in the early stages of the innovation cycle and should be awarded through competitive procedures, with export expansion serving as a market test. Targeted R&D programmes supporting the transition from onshore to offshore cables, the development of medium-power gearboxes, or diagnostic systems are appropriate applications of this instrument. Poland already has established distribution channels for such support through European funds and the National Fund for Environmental Protection and Water Management (Narodowy Fundusz Ochrony Środowiska i Gospodarki Wodnej, NFOŚiGW).

- **Targeted promotion of foreign investment** – efforts to attract foreign investment should focus on technology transfer through cooperation with Polish universities, schools, local authorities and business organisations. The Polish Investment and Trade Agency (Polska Agencja Inwestycji i Handlu, PAIH) should explicitly prioritise Phase Two segments: offshore cables, control systems and gearboxes. The successful attraction of a nacelle factory and an onshore blade manufacturing plant to Poland demonstrates that targeted investment promotion can deliver results.

- **Tax incentives for maintenance and training services in coastal counties** – sector-specific tax incentives can be an effective tool for capability development, but only in regions with an appropriate human-capital base. Poland's Baltic coast is developing a growing skills base: the Gdańsk University of Technology (Politechnika Gdańska) has launched postgraduate programmes in offshore wind energy, manufacturing companies are training workers in Szczecin, and service bases are under development in Łeba, Ustka and Władysławowo. Tax incentives for offshore maintenance and training companies, linked to GWO certification requirements, could accelerate the development of a skills base whose benefits would be realised throughout the 25–30-year operating lifetime of wind farms.
- **Cooperation with universities and technology transfer programmes** – in segments such as SCADA systems, predictive diagnostics and power electronics, Poland possesses integration capabilities (supported by a large IT sector) but lacks manufacturing capabilities. In such cases, the EBRD recommends programmes supporting cooperation between universities and the private sector in innovation activities, an approach already applied in Montenegro, Lithuania, Serbia and Slovenia. The Gdańsk University of Technology (Politechnika Gdańska), the West Pomeranian University of Technology in Szczecin (Zachodniopomorski Uniwersytet Technologiczny) and the Gdynia Maritime University (Akademia Morska w Gdyni) possess the necessary infrastructure to participate in technology-transfer programmes, provided that stable funding for research projects is ensured.

8. Photovoltaics

Role in the energy transition: photovoltaics are the primary technology for rapidly expanding low-emission generation capacity and electrifying the economy. The development of this segment strengthens competitiveness in components, electronics and specialised PV applications, while also improving energy security by increasing domestic generation capacity and reducing exposure to fuel price fluctuations.

Market outlook: cumulative installed PV capacity in the EU is expected to grow by approximately 13% annually[19] until 2030, while annual additions are projected to stabilise.[20]

Position of the EU: a political priority confronted with Chinese import dominance, resulting in Europe's dependence on external suppliers and extreme price pressure. Rapid market expansion is intended to serve as a response to Chinese expansion. Between 2019 and 2024, the value of production in the EU increased from EUR 3.9 billion to EUR 4.4 billion, while import intensity, measured as the ratio of imports to consumption, reached 163.3% in 2024.

EU strategy: photovoltaics have been designated as a net-zero technology under the Net-Zero Industry Act (NZIA).[21] The development of PV has been a pillar of REPowerEU[22] and the EU Solar Energy Strategy,[23] including the European Solar Rooftop Initiative. Requirements for the gradual deployment of solar installations on buildings were also incorporated into the revised Energy Performance of Buildings Directive (EPBD).[24] The European PV value chain was further strengthened through the launch of the European Solar PV Industry Alliance in 2022.

Position of Poland: the domestic industry is characterised by an extensive manufacturing base and relatively high technological complexity compared with other countries in the region.[25] This positions Poland as a potential beneficiary of the NZIA. Exports are growing from a low base – increasing from virtually zero in 2019 to EUR 0.62 billion in 2024. The RCA indicator for the sector stands at 0.55.

Local content: the installation sector is dominated by domestic capital, although it remains dependent on Chinese manufacturers of photovoltaic cells.

Table 5. Characteristics of Polish-owned and foreign-owned firms

Characteristic	Polish-owned firms	Foreign-owned firms
Share of revenues	98.2%	1.8%
Revenue growth (2018–2023)	38.3%	n/a
Net profitability	7.6%	0.7%
Number of patents (2001–2025)	30	0

Source: SpotData.

19 *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: EU Solar Energy Strategy* (COM(2022) 221, 18 May 2022).
20 *Ibidem.*
21 *Regulation (EU) 2024/1735 of the European Parliament and of the Council of 13 June 2024 establishing a framework of measures for strengthening Europe's net-zero technology manufacturing ecosystem and amending Regulation (EU) 2018/1724.*
22 *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: REPowerEU Plan* (COM(2022) 230, 18 May 2022).
23 *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: EU Solar Energy Strategy* (COM(2022) 221, 18 May 2022).
24 *Directive (EU) 2024/1275 of the European Parliament and of the Council of 24 April 2024 on the energy performance of buildings.*
25 World Bank, *Clean Tech Value Chains: Using Trade Data to Guide a Complex Policy Space – Part Two*, 2024.

Supply chain structure:

- **Production of raw materials and cells** – a capital- and energy-intensive stage covering the production of polysilicon, silicon wafers and photovoltaic cells. This segment is almost entirely dominated by Chinese manufacturers.
- **Module assembly** – the integration of imported cells into finished solar panels. The few Polish facilities operating in this segment mainly serve as assembly plants, producing end products from imported components while facing strong price pressure.
- **Mounting structures and installation systems** – the infrastructure on which panels are installed. In this segment, Poland has a complete and independent supply chain based on the domestic steel and aluminium industries and Polish-made components.
- **Power electronics and inverters** – the segment with the greatest potential for value-added growth. While basic cabling has long been the domain of Polish manufacturers, domestic firms are now entering the production of advanced control electronics and energy management systems, particularly inverters, which convert direct current generated by solar panels into alternating current used in the grid. This applies both to large-scale installations (companies and solar farms) and smaller-scale systems (prosumers). Poland is beginning to fill the gap between simple physical infrastructure and advanced IT solutions.
- **Distribution and system integration** – combining individual elements into a complete solution. This is the area in which Polish-owned firms have achieved the greatest success. Although these companies often trade imported products, they control the market, margins and customer relationships. This ecosystem is complemented by innovative niches (e.g. BIPV and tracking systems) and small-scale photovoltaics (off-grid solutions, systems for yachts and small electronic devices).

Table 6. Revealed comparative advantage indicators by value-chain element

Value chain element	Product name	RCA
Final product	PV DC generators, power ≤ 50 W (small electronics/off-grid)	1.75
Final product	PV AC generators (integrated)	0.9
Final product	Assembled PV panels	0.32
Final product	PV DC generators, power > 50 W	0.3
Component	Inverters > 7.5 kVA (industrial)	0.77
Component	Inverters ≤ 7.5 kVA (residential)	0.68
Component	Unassembled PV cells	0.08
Component	Photosensitive elements	0.05
Raw material	Silicon with purity ≥ 99.99%	0

Source: SpotData.

Barriers to the development of local content:

- **exchange-rate risk** – for distributors, the principal challenge remains managing exchange-rate exposure and working capital requirements associated with large-scale imports,
- **dependence on imported semiconductors** – for electronics manufacturers, the main challenge is access to integrated circuits and power components produced primarily in Asia, as well as the risk of long-term supply constraints,
- **lack of continuity in domestic support programmes** – significant fluctuations in demand make stable sector development difficult, regardless of its overall scale,
- **infrastructure constraints** – the curtailment of installations during periods of electricity oversupply reduces the predictability of investment returns, particularly for smaller market participants.

Development niches:

The development potential of Poland's photovoltaic sector lies not in the module itself, but in everything around it (balance of system). By expanding the existing model, synergies can be created between advanced structures, electronics and distribution. Profits should be reinvested in increasingly sophisticated technologies. Potential areas for development include:

- **distribution and services** – Polish companies are emerging as European leaders in supply-chain management, and this advantage should be further strengthened,
- **construction systems industry** – by leveraging its strong base in steel and aluminium processing, Poland has become a manufacturing hub for mounting systems. In addition, geographical proximity to export markets, particularly Germany—the largest PV market in Europe—provides Polish manufacturers of heavy steel structures with a competitive advantage over suppliers from Asia,
- **power electronics** – the exponential growth in inverter production creates an opportunity to establish an alternative to Western brands by offering devices with a strong price-to-quality ratio and full compatibility with European grid-security standards.

Beyond reach by 2030:

- **large-scale photovoltaic cell manufacturing –** although ambitious domestic projects exist, they must compete with the cost advantages of Chinese manufacturers and require extremely substantial capital support.

Recommendations for public policy:

1. **A retrofit strategy as a complement to new capacity** – rather than focusing exclusively on new installations, support programmes should place greater emphasis on upgrading existing systems (retrofit). Equipping them with energy storage systems and hybrid inverters would increase self-consumption in residential installations and improve system flexibility without placing additional strain on the grid.
2. **Stimulating new categories of PV installation locations** – given that the value added created by Polish firms lies in system integration, encouraging new installation locations (e.g. agrivoltaics) could serve as a testing ground for innovative solutions that address both domestic and international market needs.
3. **R&D grants for niche segments** – innovation funding should be directed towards manufacturers of advanced electronics, including inverters and home energy management systems (HEMS), in order to maintain growth momentum in the high-tech segment. Public support should focus on those areas where Poland already possesses genuine manufacturing capabilities: system integration, mounting structures and control electronics, rather than module production.

9. Electromobility

Role in the energy transition: electromobility is a key pathway for decarbonising road transport, covering passenger cars, buses and heavy-duty vehicles. The development of this segment reduces transport dependence on imported oil while simultaneously increasing the importance of access to critical raw materials and battery components.

Market outlook: global growth of approximately 12% annually until 2030.[26] The passenger electric vehicle market remains the primary driver of growth, although following a period of very rapid expansion it is expected to stabilise gradually. The electrification of public transport, particularly urban buses, is progressing faster than in the coach and heavy-duty transport segments, where the pace of change is likely to remain slower.[27] The global charging infrastructure market is growing at around 25% annually.[28]

Position of the EU: the automotive industry is considered one of Europe's flagship industries, but it entered the EV segment relatively late and consequently ceded part of the market to competitors. Import intensity, measured as the ratio of imports to consumption, reached 60.6% in 2024. At the same time, the value of EU production increased from EUR 170.1 billion in 2019 to EUR 271.8 billion in 2024.

EU strategy: the EU has introduced binding CO_2 emission standards for new passenger cars, vans[29] and heavy-duty vehicles.[30] Demand in the bus segment and parts of commercial fleets is reinforced by the Clean Vehicles Directive[31] through public-procurement targets, while the deployment framework is supported by the Alternative Fuels Infrastructure Regulation (AFIR),[32] which includes requirements for charging infrastructure expansion. The Industrial Action Plan for the *European Automotive Sector*[33] sets out a strategy for maintaining the competitiveness of the sector during the transition towards zero-emission and automated vehicles.

Position of Poland: the automotive industry is one of the pillars of Polish exports. Poland is an important manufacturing centre for vehicles, and particularly for vehicle parts and components, as well as a European hub for electric bus production. The country also possesses a clear comparative advantage in hybrid heavy-duty vehicles and benefits from a strong industrial base in heavy transport, although this remains dependent on imported components and raw materials. A well-developed transport and logistics sector further strengthens potential domestic demand. However, the Polish automotive sector lags behind in terms of the energy transition and therefore is unlikely to be among the first beneficiaries of the shift towards clean technologies. At the same time, the scale of domestic road transport, logistics and e-commerce creates a substantial market for new energy solutions. Between 2019 and 2024, the value of Polish exports increased from EUR 14.20 billion to EUR 25.13 billion, while the RCA indicator for the sector stands at 1.83.

26 BloombergNEF, *Global Electric Vehicle Sales Set for Record-Breaking Year, Even as US Market Slows Sharply*, BloombergNEF Finds, 2025.
27 IEA, *Global EV Outlook 2025*, 2025.
28 J. Foster, *Global electric bus charging infrastructure market to experience exponential growth*, EVC&I, 2023.
29 *Regulation (EU) 2019/631 of the European Parliament and of the Council of 17 April 2019 setting CO_2 emission performance standards for new passenger cars and new light commercial vehicles and repealing Regulations (EC) No 443/2009 and (EU) No 510/2011, as amended by Regulation (EU) 2023/851 of the European Parliament and of the Council of 19 April 2023 amending Regulation (EU) 2019/631 as regards strengthening the CO_2 emission performance standards for new passenger cars and new light commercial vehicles in line with the Union's increased climate ambition, commonly known as the ban on the sale of new internal combustion engine vehicles after 2035.*
30 *Regulation (EU) 2019/1242 of the European Parliament and of the Council of 20 June 2019 setting CO_2 emission performance standards for new heavy-duty vehicles and amending Regulations (EC) No 595/2009 and (EU) 2018/956 and Council Directive 96/53/EC, as amended by Regulation (EU) 2024/1610 of the European Parliament and of the Council of 14 May 2024 amending Regulation (EU) 2019/1242 as regards strengthening the CO_2 emission performance standards for new heavy-duty vehicles and integrating reporting obligations, amending Regulation (EU) 2018/858 and repealing Regulation (EU) 2018/956.*
31 *Directive (EU) 2019/1161 of the European Parliament and of the Council of 20 June 2019 amending Directive 2009/33/EC on the promotion of clean and energy-efficient road transport vehicles.*
32 *Regulation (EU) 2023/1804 of the European Parliament and of the Council of 13 September 2023 on the deployment of alternative fuels infrastructure and repealing Directive 2014/94/EU.*
33 *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Industrial Action Plan for the European Automotive Sector* (COM(2025) 95, 5 March 2025).

Local content: in the passenger car and heavy-duty vehicle segments, both manufacturing and sales have been built almost entirely on foreign capital. Domestic firms primarily operate as lower-tier suppliers. In the electric and hybrid bus segment, however, Poland possesses strong design and manufacturing capabilities.

Table 7. Characteristics of Polish-owned and foreign-owned firms

Characteristic	Polish-owned firms	Foreign-owned firms
Share of revenues	6.5%	93.5%
Revenue growth (2018–2023)	37.9%	63.9%
Net profitability	1.4%	3.0%
Number of patents (2001–2025)	25	13

Source: SpotData.

Supply chain structure:

- **Raw materials and basic materials** – Poland has strong advantages in specific material niches, including silicon electrical steel and alloy steel scrap. This means that the Polish metallurgy and recycling industries have successfully integrated into the EV supply chain by providing materials required for motor and vehicle structure manufacturing.
- **Mechanical components (tier 2/3)** – this segment is dominated by foreign-owned European and American companies. Factories located in Poland specialise in suspension and chassis components that are required regardless of the vehicle's propulsion technology, including shock absorbers, forged steering components and non-driven axle parts.
- **Key technologies (batteries, chargers and drivetrains)** – this is the highest-value segment and is dominated by foreign capital. Poland is Europe's leading exporter of lithium-ion batteries thanks to a single foreign investor. Nevertheless, there are technologies – such as EV charging infrastructure – in which domestic firms have achieved significant success.
- **Vehicles** – foreign companies dominate this segment in terms of production volumes. Poland nevertheless maintains a strong position in selected niches, including buses and commercial vehicles.
  - **Passenger cars** – Poland primarily serves as an assembly base for foreign automotive groups. There is no significant specialisation in electric or hybrid passenger vehicles.
  - **Buses** – Poland is a European leader, including in R&D activities, with a dominant position in exports of hybrid and electric buses. Other foreign manufacturers from this segment also operate production facilities in Poland. Following ownership changes within the industry, some Polish-owned firms remain, although their market position is considerably smaller.
  - **Heavy-duty vehicles** – Poland has a clear comparative advantage in hybrid heavy-duty vehicle manufacturing, while lacking full specialisation in fully electric vehicles. Production is concentrated in several strategically important European-scale facilities, many of which are currently undergoing electrification. In the specialised segment, military applications also play an important role.

Table 8. Revealed comparative advantage indicators by value-chain element

Value chain element	Product name	RCA
Final product	Hybrid buses	33.87
Final product	Electric buses	7.3
Final product	Diesel delivery trucks	3.96
Final product	Hybrid delivery trucks	3.46
Final product	Diesel buses (conventional)	2.19
Final product	Electric delivery trucks	0.93
Final product	Hybrid passenger cars	0.83
Final product	Electric bicycles	0.42
Final product	Electric passenger cars	0.23
Component	Shock absorbers	8.25
Component	Forged steering-system parts	5.77
Component	Lithium-ion batteries	5.01
Component	Non-driven axle parts	4.9
Component	Disc brake pads	3.85
Component	Forged driven-axle parts	3.71
Component	Steering columns and boxes	3.55
Component	Aluminium wheels	3.05
Component	Electric motors DC (750 W - 75 kW)	2.84
Component	Electric motors DC large (> 375 kW)	2.24
Component	Ignition cables and other wiring sets	1.98
Raw material	Silicon electrical steel	12.8
Raw material	Alloy-steel waste and scrap	5.85
Raw material	Unwrought aluminium alloys	2.4

* Vehicles and buses equipped with compression-ignition engines are incorporated into the analysis to serve as a comparative benchmark and a technological foundation for transition, as opposed to being classified as clean technologies sensu stricto.
Source: SpotData.

Barriers to the development of local content:

- **margin and ownership structure** – Polish-owned firms operate with low revenues and low profit margins, limiting their ability to invest in R&D and innovation,
- **energy costs** – a critical factor for energy-intensive battery and materials manufacturing.

Development niches:

- **Zero-emission heavy transport** – Poland is a logistics powerhouse, creating a large domestic market for the deployment of new technologies. However, the segment remains conservative due to market fragmentation and the limited financial capacity of many companies. High specialisation indicators in the bus segment provide an advantage that can partially be transferred to the commercial vehicle and heavy-duty vehicle markets. Charging stations constitute an important part of the ecosystem and remain at an early stage of transformation. In selected applications, particularly in the last-mile segment of the supply chain, electrification is beginning to become economically viable. Although this market remains behind in the energy transition, it may generate substantial domestic demand for new technologies in the future.
- **Integrated systems for EV platforms** – leveraging existing specialisation in mechanical components (shock absorbers, axles and steering systems) used in internal combustion vehicles may provide a foundation for increasing value added in electromobility. Moving from low-margin component manufacturing towards the high-margin design of complete systems for electric vehicles would be beneficial for the Polish economy, but depends on ownership structures and the position of firms within larger corporate groups. Nevertheless, with a strong base in silicon electrical steel and forged component manufacturing, Poland can attract further processing stages and increase domestic value added.

- **Software-defined vehicles (SDVs)** – software is taking over an increasing number of functions in modern vehicles. This creates an opportunity for Poland to leverage the strength of its IT sector and build specialisations in software for autonomous vehicles and cybersecurity solutions. Such a strategy would allow the country to move beyond component manufacturing. However, success will require the development of an appropriate legislative framework and supporting infrastructure, including testing facilities for autonomous technologies.

Beyond reach by 2030:

- **mass production of passenger cars** – at a scale that would be globally competitive. At least until 2030, decisions regarding the allocation of electric vehicle production are likely to remain concentrated at the headquarters of multinational corporations.

Recommendations for public policy:

The solution lies in adapting the existing automotive industry to the electrification megatrend. This means transforming the experience and expertise gained through the production of internal combustion vehicles into capabilities for manufacturing and exporting low-emission transport solutions and the infrastructure that supports them.

1. **Target support towards the bus and commercial vehicle sectors** – given Poland's genuine competitive advantage, public policy should prioritise support for the development and export of Polish electric buses rather than focusing exclusively on passenger cars.
2. **Support the transformation of suppliers** – support programmes should help manufacturers of mechanical components adapt to the requirements of electromobility, for example through lighter materials and greater integration with electronics. This would allow them to maintain their strong position within supply chains.
3. **Develop battery recycling as a new specialisation** – Poland should build on its strong position in raw materials, steel scrap and copper recycling to establish a battery recycling hub. This would help retain valuable materials within the domestic economy. In the longer term, some batteries could also be used in second-life applications, such as stationary energy storage systems, before undergoing full recycling.
4. **Pursue a sovereign investment attraction strategy** – given diverging economic interests within the EU, Poland should develop its own strategy for attracting investors. Incentives and tax breaks offered to foreign corporations should be conditional on cooperation with local research institutions and manufacturers, as well as meaningful industrial offset arrangements, rather than creating effectively "extraterritorial" facilities isolated from local suppliers.
5. **Ensure that the ElectroMobility Poland project delivers genuine technology transfer** – the ElectroMobility Poland project should contribute to real technology transfer and the development of a local value chain through a joint-venture model, rather than serving merely as an assembly operation for ready-made components imported from China that only formally satisfy local-content requirements.

10. Rail

Role in the energy transition: rail transport is one of the most important tools for decarbonising passenger and freight transport because it enables traffic to shift away from more emissions-intensive modes. The development of this segment reduces the energy intensity of transport, meaning the amount of energy consumed per unit of transport work performed.

Market outlook: approximately 6% annual growth in the EU until 2030.[34]

Position of the EU: European companies maintain a strong position, although far from a monopoly. The sector exhibits moderate import intensity (28%). Most final demand is met by EU suppliers. Between 2019 and 2024, the value of production in the EU increased from EUR 20.1 billion to EUR 21.3 billion, while import intensity, measured as the ratio of imports to consumption, stood at 27.8% in 2024.

EU strategy: rail has been identified as a pillar of transport decarbonisation in the Sustainable and Smart Mobility Strategy.[35] Infrastructure development and interoperability are supported by the revised TEN-T Regulation,[36] while cross-border passenger services are promoted through the *Action Plan to Boost Long-Distance and Cross-Border Passenger Rail*.[37] The sector's research and innovation dimension is implemented through the Europe's Rail institutional partnership under Horizon Europe[38] and its predecessor, Shift2Rail.

Position of Poland: Poland plays an important role in the European rail market thanks to its almost complete and competitive supply chain. The country has its own tier-one manufacturers competing with global corporations and producing complete vehicles under their own brands, including locomotives, passenger coaches, multiple units and trams. Production in this sector is not dependent on imports to the same extent as in many other industries, giving Poland a relatively high degree of independence as both a manufacturer and a net exporter. Between 2019 and 2024, the value of Polish exports increased from EUR 1.46 billion to EUR 2.04 billion, while the RCA indicator for the sector stands at 2.29.

Local content: the sector operates on a large scale and is dominated by Polish-owned capital. Domestic champions are important players on the European market in terms of market share, manufacturing and export expansion, and technological sophistication. The industry is characterised by a high degree of technological and capital sovereignty, although limitations remain in the most advanced control systems and in the high-speed rail segment. Polish firms are increasingly acting as consolidators within the European market, acquiring foreign assets to gain access to new markets and capabilities. Foreign companies also continue to establish manufacturing facilities in Poland.

34 R. Chapuis, T. Delporte, S. Köpke, C. Lotz, A. Ott, *Bold moves to boost European rail freight,* McKinsey, 2022.
35 *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Sustainable and Smart Mobility Strategy – Putting European Transport on Track for the Future* (COM(2020) 789, 9 December 2020).
36 *Regulation (EU) 2024/1679 of the European Parliament and of the Council of 13 June 2024 on Union guidelines for the development of the trans-European transport network, amending Regulations (EU) 2021/1153 and (EU) No 913/2010 and repealing Regulation (EU) No 1315/2013.*
37 *Communication from the Commission to the European Parliament and the Council: Action Plan to Boost Long-Distance and Cross-Border Passenger Rail* (COM(2021) 810, 14 December 2021).
38 *Council Regulation (EU) 2021/2085 of 19 November 2021 establishing the Joint Undertakings under Horizon Europe and repealing Regulations (EC) No 219/2007, (EU) No 557/2014, (EU) No 558/2014, (EU) No 559/2014, (EU) No 560/2014, (EU) No 561/2014 and (EU) No 642/2014.*

Table 9. Characteristics of Polish-owned and foreign-owned firms

Characteristic	Polish-owned firms	Foreign-owned firms
Share of revenues	57.9%	42.1%
Revenue growth (2018–2023)	40.6%	93.6%
Net profitability	6.4%	3.4%*
Number of patents (2001–2025)	19	13

* Small sample.

Source: SpotData.

Supply chain structure:

- **Infrastructure and track systems** – a segment dominated by companies with Polish private capital. Poland is largely self-sufficient in the production of railway track components, and domestic companies supply key elements such as turnouts, sleepers, and fastening systems.
- **Mechanical components and equipment** – both domestic and foreign capital are present in this segment. Simple metal components and forgings are produced by Polish companies, while more advanced mechanical subsystems are largely controlled by foreign (American and European) capital that acquired former Polish plants. A particular strength of domestic companies lies in freight wagons and tanks (Poland is a European leader in the production of tank wagons). Poland is also rebuilding its position in the freight wagon manufacturing industry.
- **Electronics, drives and control systems** – Poland has the capability to manufacture critical components in this area. A Polish manufacturer is a global leader in inverters and modern drive systems supplied to metro systems, trams and trains worldwide. Domestic companies also hold a strong position in passenger information and communication systems. The presence of both domestic and foreign enterprises means that many technologically advanced rail vehicle components are manufactured in Poland.
- **Rolling stock manufacturing** – at this highest level of the value chain, Poland has both private and state-owned manufacturers, many of which originated as railway rolling stock repair facilities. Competition comes from European companies that carry out part of their production in Poland. On the Polish market, and in some segments also at the regional European level, the largest domestic firms compete directly with facilities owned by foreign manufacturers.

Table 10. Revealed comparative advantage indicators by value-chain element

Value chain element	Product name	RCA
Final product	Self-propelled wagons/traction units (diesel/other sources)	18.75
Final product	Self-propelled wagons/traction units (electric)	7.17
Final product	Covered/enclosed freight wagons	7.02
Final product	Self-discharging wagons	5.5
Final product	Tank wagons	1.99
Final product	Other goods wagons	1.5
Final product	Rail locomotives powered by external electricity	0.74
Final product	Passenger wagons not self-propelled	0.34
Component	Coupling devices, hooks and buffers	8.95
Component	Bogies and half-bogies	3.85
Component	Other parts of railway rolling stock	3.6
Component	Unimpregnated wooden railway sleepers	7.01
Component	Heavy Vignole rails (≥ 36 kg/m)	4.44
Component	Used rails (recycling/reprocessing)	3.65
Component	Conductor rails (third rail)	2.97
Component	Light Vignole rails (< 36 kg/m)	2.22
Component	Turnout components (switch blades, crossings)	1.95

Component	Impregnated wooden sleepers	1.91
Component	Fishplates and baseplates	1.7
Component	Axles and wheels	0.96
Component	Parts of electrical signalling equipment	0.52
Raw material	Alloy-steel scrap	5.85

Source: SpotData.

Barriers to the development of local content:

- **financing of large export contracts** – rolling stock manufacturing requires substantial working capital, while foreign industry giants benefit from support from governments and financial institutions,[39] making it more difficult for Polish companies to compete for the largest tenders outside Poland,
- **demand fluctuations** – Polish plants are only beginning to scale up their operations, and the sector's development has been driven to a significant extent by European funds; railway rolling stock procurement will continue to receive support, therefore the ability to balance demand over time through phased orders from different customers is important; demand patterns may also change as a result of market liberalisation following the Fourth Railway Package, including the potential development of so-called rolling stock pools, in which vehicles are made available to multiple operators.

Development niches:

- **assembly of specialised systems** – including battery systems,
- **advanced components** – such as pneumatic braking systems, powered bogies and their parts, and, in the longer term, lighter structural materials and solutions improving the energy efficiency of rolling stock.

Beyond reach by 2030:

- **advanced safety systems** – despite the presence of domestic companies, the railway signalling and traffic control systems market remains small, and Poland is dependent on imports in this area,
- **selected mechanical components** – as a result of the privatisations of the 1990s, the production of wheels, axles, braking systems and couplers came under foreign ownership, although the factories remain located in Poland.

Recommendations for public policy

1. **Support for R&D in components** – targeted grants for the development of Polish railway signalling and control systems (SRK/ETCS) and mechanical components, in order to reduce imports in the few areas where dependence on foreign manufacturers still exists.
2. **Support for the next technological breakthrough in the sector** – through competitions focused on solving key industry challenges, particularly in railway control systems and high-speed rail. In the case of the 250 km/h+ segment, the objective should be to build competencies over the long term rather than achieve rapid results in the coming years.
3. **Support for rolling stock certification** – facilitating the financing and organisation of certification processes so that Polish manufacturers can more easily enter foreign markets and scale up exports.

39 Examples of government support provided to Siemens include: (1) export guarantees, such as for the "Green Line" project in Egypt (a 660 km railway line), where the government assumed responsibility for financing the bank loan and provided coverage for delivery and production risks (https://www.exportkreditgarantien.de/de/beispielprojekte/green-line-der-suez-kanal-auf-schienen.html), 2) guarantees worth EUR 7.5 billion granted to Siemens Energy (https://www.reuters.com/business/energy/german-government-unveils-deal-siemens-energy-guarantees-2023-11-14/).

11.
Heating systems

Role in the energy transition: heat pumps and modern heating and cooling systems are technologies that should be developed in parallel with building renovation programmes, as they are key elements of building decarbonisation. They reduce the consumption of fossil fuels and, consequently, the need to import them. Combined with smart control systems and thermal energy storage, they can also contribute to increasing the flexibility of the Polish power system (KSE).

Market outlook: approximately 8% annual global growth is expected through 2030.[40] The International Energy Agency (IEA) estimates that, in order to achieve climate targets, global investments in energy efficiency would need to triple by 2030, reaching around USD 1.9 trillion.[41]

Position of the EU: production value is increasing, but competition from outside the EU is also growing. The market is not dominated by imports from any single source. Between 2019 and 2024, the value of EU production increased from EUR 5.7 billion to EUR 6.8 billion, while import intensity (measured as the ratio of imports to consumption) reached 60.2% in 2024.

EU strategy: heat pumps and geothermal technologies are classified as net-zero technologies under the NZIA regulation.[42] In addition, the revised Energy Performance of Buildings Directive (EPBD)[43] strengthens incentives by gradually phasing out fossil-fuel boilers and creating a pathway away from fossil fuels in heating. Targets for increasing the share of renewable energy in heating and cooling are established under RED III,[44] while technological developments in the sector are shaped by the F-gas[45] and Ecodesign regulations.[46] Another important framework is the EU's Renovation Wave[47] initiative, which aims to double the annual building renovation rate to 2%. The REPowerEU strategy[48] assumes that nearly 60 million heat pumps will be operating across the EU by 2030.

Position of Poland: Poland is gradually emerging as a new leader in this segment. Within five years, the country has evolved from a technology importer into a country with an average but growing export specialisation. This ecosystem also includes thermal renovation materials such as windows and doors, mineral wool, and insulation systems, in which Poland holds a significant position within the EU. Between 2019 and 2024, the value of Polish exports increased from EUR 0.16 billion to EUR 0.41 billion, while the RCA indicator for the sector rose to 1.00.

40 IEA, *Tracking energy efficiency investment progress*, 2024.
41 *Ibidem*.
42 *Regulation (EU) 2024/1735 of the European Parliament and of the Council of 13 June 2024 establishing a framework of measures for strengthening Europe's net-zero technology manufacturing ecosystem and amending Regulation (EU) 2018/1724*.
43 *Directive (EU) 2024/1275 of the European Parliament and of the Council of 24 April 2024 on the energy performance of buildings*.
44 *Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources and repealing Council Directive (EU) 2015/652*.
45 *Regulation (EU) 2024/573 of the European Parliament and of the Council of 7 February 2024 on fluorinated greenhouse gases, amending Directive (EU) 2019/1937 and repealing Regulation (EU) No 517/2014*.
46 Including, among others, *Commission Regulation (EU) No 813/2013 of 2 August 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for space heaters and combination heaters;* and *Commission Regulation (EU) No 206/2012 of 6 March 2012 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for air conditioners and comfort fans*.
47 *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: A Renovation Wave for Europe – Greening Buildings, Creating Jobs, Improving Lives* (COM(2020) 662, 14 October 2020).
48 *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: REPowerEU Plan* (COM(2022) 230, 18 May 2022).

Local content: domestic firms retain a large share of the market. They compete successfully on quality and margins, building a lasting position within the European supply chain. Innovation in this sector is largely driven by Polish capital, with domestic R&D departments developing the technical expertise needed to improve products. In the heat pump segment itself, foreign capital dominates, but factories established in Poland by foreign corporations attract suppliers and strengthen the local supply chain.

Table 11. Characteristics of Polish-owned and foreign-owned firms

Characteristic	Polish-owned firms	Foreign-owned firms
Share of revenues	48.2%	51.8%
Revenue growth (2018–2023)	48.0%	54.4%
Net profitability	4.9%	3.8%
Number of patents (2001–2025)	161	14

Source: SpotData.

Supply chain structure:

- **Raw materials and basic materials** – in this segment, Poland specialises in unwrought aluminium alloys, which are essential for the production of heat exchangers and enclosures. The country also has a strong market for insulation and construction materials, which is highly important for thermal renovation.
- **Components and subassemblies** – Polish companies are building a niche in control systems (control boards and control panels), leveraging their expertise in automation and electronics used in heating systems. In components for refrigeration equipment and heat pumps, Poland maintains average European competitiveness. This is a key area for Polish suppliers to develop alongside new factories established by foreign manufacturers.
- **Final products** – this is the segment in which Poland has achieved success. In heat pumps, Poland has developed an export specialisation (particularly noteworthy is its strong technological position in ground-source heat pumps), with exports increasing more than tenfold over five years. Poland also holds a strong position in split-system air conditioners. Domestic companies are recording triple-digit revenue growth, successfully competing with foreign firms through innovative products. Solar thermal collectors are another Polish niche, with domestic manufacturers maintaining a strong position both on the domestic market and in exports.

Table 12. Revealed comparative advantage indicators by value-chain element

Value chain element	Product name	RCA
Final product	Heat pumps	1.39
Final product	Air conditioners type "split-system"	1.36
Final product	Packaged air conditioners	0.43
Final product	Induction or dielectric furnaces and ovens	0.6
Final product	Other industrial furnaces	0.15
Component	Parts of refrigerating equipment and heat pumps	1.02
Component	Glandless circulation pumps	0.51
Component	Control panels and switchboards	1.82
Component	Parts of industrial furnaces (induction)	0.37
Component	Parts of furnaces for the production of printed circuits	0.05
Raw material	Unwrought aluminium (alloys)	2.4
Raw material	Copper waste	0.9
Raw material	Glass wool	0.11

Source: SpotData.

Barriers to the development of local content:

- **dependence on imported components** – many elements (e.g. advanced compressors and glandless circulation pumps) must be imported, making final-product manufacturers dependent on external suppliers,
- **low brand recognition** – the market share of Polish brands in domestic sales still does not exceed 5%. This means that Poland is recognised as a manufacturing base, but trade and distribution continue to be dominated by foreign brands supported by stronger marketing,
- **instability of support schemes** – frequent changes in support programmes (e.g. the Clean Air programme) create demand fluctuations, making it difficult for smaller Polish companies to plan investments in production capacity,
- **unfavourable electricity pricing** – the high cost of electricity relative to natural gas may discourage some customers from purchasing electrified heating devices, particularly when they do not use time-of-use or dynamic tariffs.

Development niches:

- **consolidating Poland's position as a European heat pump manufacturing hub** – the presence of global industry leaders combined with dynamic domestic firms creates a cluster effect. This attracts component suppliers (compressors and heat exchangers), shortens supply chains and reduces production costs,
- **development of Polish control technologies** – high levels of innovation and specialisation in control panels enable Polish companies to offer not only equipment but also intelligent heat management systems, where margins are higher,
- **materials for thermal renovation and energy-efficiency improvements** – further strengthening Poland's export position in insulation systems and high-performance windows and doors,
- **development of energy control and management technologies** – building on experience in automation, Polish companies can develop intelligent heat management systems (HEMS/BEMS) and solutions enabling devices to be integrated with energy markets (flexibility services),
- **hybrid and specialised solutions** – integrating ground-source heat pumps with solar installations and thermal energy storage, as well as developing domestic engineering capabilities in large-scale equipment for district heating systems.

Beyond reach by 2030:

- **key mechanical components for heat pumps** – particularly advanced compressors and glandless circulation pumps. Poland is likely to remain dependent on imports in these areas, even if growing market scale attracts new suppliers,
- **strong mass-market consumer brands** – despite growing production and export capabilities, the share of Polish brands in domestic sales remains low, making it difficult to build a market position comparable to the largest international brands by 2030.

Recommendations for public policy:

1. **Support for Polish brands** – promote domestic manufacturers through subsidy programmes in order to increase their share of the domestic market. One approach used in other EU countries is to design procurement criteria in a way that can be met by local suppliers.
2. **Investment in components** – incentives for both domestic and foreign investors to locate compressor and control electronics production in Poland, thereby completing the supply chain and increasing domestic value added.
3. **Regulatory stability** – ensuring attractive electricity tariffs for heat-pump users, which would stabilise demand and allow Polish companies to scale production safely.
4. **Sector agreement for clean heat** – following the example of other industries (such as offshore wind and hydrogen production), it is important to formally strengthen cooperation between government administration, manufacturers, the scientific community and the financial sector. The objective should be better coordination of activities, the systematic removal of regulatory barriers and support for the international expansion of Polish firms.

12.
Grids and transformers

Role in the energy transition: grid infrastructure, cables and transformers determine the pace at which renewable energy installations can be connected to electricity networks, as well as the electrification of industry, transport and heating, and the integration of new energy sources and consumers. The development of this segment improves system security by increasing capacity, reliability and resilience to disruptions.

Market outlook: approximately 7–9% annual growth until 2030.[49] According to the IEA, global investment in grid infrastructure must double by the end of this decade, reaching more than USD 600 billion per year by 2030[50] (around 9% annual growth). In 2025, annual spending on electricity grids in the EU exceeded USD 70 billion,[51] compared with around USD 35 billion a decade earlier. This corresponds to an annual growth rate of approximately 7%.

Position of the EU: the European market for grids and transformers is growing rapidly, but is increasingly experiencing supply-side constraints. Very high import intensity – reaching 106.6% – demonstrates reliance on external suppliers of components. Between 2019 and 2024, the value of production in the EU increased from EUR 39.0 billion to EUR 48.9 billion.

EU strategy: cables and transformers are treated as strategic components of electricity-grid expansion. Under the Net-Zero Industry Act (NZIA),[52] they fall within the category of grid technologies, and the regulation explicitly highlights the need to increase manufacturing capacity for onshore and offshore cables, electrical substations and transformers. REPowerEU[53] further reinforces their importance as a prerequisite for accelerating grid investments, while the infrastructure framework for cross-border projects, smart grids, and offshore energy infrastructure is established by the TEN-E Regulation.[54] Meanwhile, the measures set out in the EU Action Plan for Grids[55] shift the focus towards supply chain resilience by highlighting increasing lead times for grid components, including high-voltage cables, and the need for greater standardisation and improved visibility across procurement chains to facilitate the scaling-up of European manufacturing.

Position of Poland: this is one of the best-performing areas of Polish industry, with a competitive position within the EU. The primary driver is the energy transition. Between 2019 and 2024, the value of Polish exports increased from EUR 2.60 billion to EUR 5.73 billion. The RCA indicator for the entire sector stands at 1.08.

Local content: dynamic growth combined with a strong position of domestic firms. More than half of sector revenues are generated by companies with Polish capital.

49 IEA, *Electricity Grids and Secure Energy Transitions*, 2023.
50 *Ibidem*.
51 J.C. Laloux, *The missing link in Europe's energy transition,* 2025.
52 *Regulation (EU) 2024/1735 of the European Parliament and of the Council of 13 June 2024 establishing a framework of measures for strengthening Europe's net-zero technology manufacturing ecosystem and amending Regulation (EU) 2018/1724.*
53 *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: REPowerEU Plan* (COM(2022) 230, 18 May 2022).
54 *Regulation (EU) 2022/869 of the European Parliament and of the Council of 30 May 2022 on guidelines for trans-European energy infrastructure, amending Regulations (EC) No 715/2009, (EU) 2019/942 and (EU) 2019/943 and Directives 2009/73/EC and (EU) 2019/944, and repealing Regulation (EU) No 347/2013.*
55 *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Grids, the Missing Link – An EU Action Plan for Grids* (COM(2023) 757, 28 November 2023).

Table 13. Characteristics of Polish-owned and foreign-owned firms

	Polish-owned firms	Foreign-owned firms
Share of revenues	54.6%	45.4%
Revenue growth (2018–2023)	65.1%	89.5%
Net profitability	6.4%	3.4%
Number of patents (2001–2025)	115	12

Source: SpotData.

Supply chain structure:

- **Raw materials and semi-finished products** – Poland has access to copper and aluminium while remaining a net importer of key materials such as transformer laminations and transformer cores. The absence of a domestic manufacturing base makes the sector dependent on external suppliers, primarily from Asia.
- **Passive components (cables and accessories)** – the production of cables and wires is the domain of strong domestic companies operating at a scale that enables effective competition in international markets. Export expansion in cables rated above 1,000 V has increased the trade surplus in recent years.
- **Node equipment (transformers and substations)** – this is the segment in which Polish firms achieve their greatest commercial success, demonstrating the ability to manufacture advanced, high-value-added equipment. Specialisation in distribution transformers and container substations aligns perfectly with the needs of decentralised renewable energy systems, including outside Poland, as reflected in export statistics.
- **Smart grids and automation** – an area of growing importance driven by regulatory requirements. Polish firms possess capabilities in metering systems and IT solutions, while foreign suppliers continue to dominate the power-electronics hardware segment (rectifiers). However, the first product categories are emerging that are becoming attractive Polish export products, such as electronic assemblies for switching equipment used in energy management and static converters used for electricity conversion, including for photovoltaic and wind farms.

Table 14. Revealed comparative advantage indicators by value-chain element

Value chain element	Product name	RCA
Final product	Oil transformers ≤ 650 kVA	6.95
Final product	Oil transformers 650-1600 kVA	3.24
Final product	Static converters	1.3
Final product	Rectifiers	1.08
Final product	Oil transformers > 10 000 kVA	0.95
Final product	Automatic circuit breakers ≤ 1000 V	1.08
Final product	Inverters > 7,5 kVA	0.77
Final product	Dry-type transformers 16-500 kVA	0.8
Component	Electrical conductors > 1000 V (copper)	2.25
Component	Electrical conductors > 1000 V (other/aluminium)	1.98
Component	Ferrite cores	3.53
Component	Control boards, panels and cabinets	1.82
Component	Electronic assemblies for switchgear	1.45
Component	Conductors ≤ 1000 V with connectors (harnesses)	1.45
Component	Transformer and coil parts	1.28
Component	High-current circuit breakers (> 63 A)	0.92
Component	Parts for "wafer probers" (semiconductor testing equipment)	6.78
Raw material	Electrical steel	12.8
Raw material	Copper waste	0.9
Raw material	Permanent magnets (metal)	0.49

Source: SpotData.

Barriers to the development of local content:

- **dependence on imported components** combined with growing export demand for finished products; this creates a risk that Polish manufacturers could become merely assembly operations dependent on the prices and availability of Asian components.

Development niches:

- **transformers and cables** – the current investment wave in Europe should be used to support the expansion of Polish transformer and cable manufacturers. The profitability and quality of products offered by domestic firms provide a competitive advantage in tenders for the modernisation of electricity distribution networks across EU countries. In the cables and wires segment, a rapid technological transition is expected, creating an opportunity that Poland is well positioned to exploit,
- **digitalisation of the energy sector** – the digitalisation of energy systems creates an opportunity for the development of the domestic market. The large-scale rollout of advanced metering infrastructure (AMI) and the need to manage low-voltage networks with a growing number of prosumers generate natural demand for Polish IT and automation solutions. Smart-grid technologies should be developed and tested in Poland, creating a foundation for scaling these solutions to foreign markets.

Beyond reach by 2030:

- **manufacturing capabilities in magnetic semi-finished products (transformer cores and high-grade silicon electrical steel) –** this remains the sector's Achilles' heel, generating a trade deficit and creating supply-chain disruption risks,
- **a strong position in the production of advanced grid power electronics (large inverters, HVDC systems and STATCOMs)** – despite growth, categories such as rectifiers and static converters continue to record a trade deficit. Foreign capital identified this gap more quickly, and foreign-owned companies operating in Poland are recording exponential revenue growth, filling niches in which Polish capital has a smaller presence.

Recommendations for public policy:

The Polish grids and transformers sector has the potential to become a secure and geographically close supply hub for key components required by the modernisation of the EU energy system. This potential is built on two solid pillars: a broad cable-manufacturing base and a strong transformer sector.

1. **Completing the supply chain** – priority should be given to attracting investment or supporting domestic firms in launching the production of transformer cores and silicon electrical steel in Poland. This would retain a larger share of value added within the country and reduce the trade deficit in this segment.
2. **Transformation towards smart solutions** – support R&D for companies moving from the production of passive components (cables, enclosures) towards active and intelligent devices (grid automation, energy management). This should include leveraging the capabilities of Polish IT companies to create integrated hardware-and-software solutions.
3. **Support for service exports** – Polish engineering, construction and installation companies operating in the electricity-network sector have export potential. A model should be promoted in which a Polish contractor executing a foreign project also supplies Polish-made transformers and cables as part of a bundled offering.

13.
Circular economy

Role in the energy transition: the circular economy closes the lifecycle of cleantech technologies through material recovery, component reuse and the development of recycling. The growth of this segment improves resource security by reducing dependence on imports when access to primary resources is limited, while also enabling a greater share of value added from the recovery and processing of critical materials to remain within the country.

Market outlook: approximately 10% annual growth in the EU.[56]

Position of the EU: relatively high import intensity, at around 60%, although the market is inherently local and regional, which supports the development of domestic capabilities. Between 2019 and 2024, the value of production in the EU increased from EUR 6.8 billion to EUR 10.9 billion.

EU strategy: a transition from the linear model (extraction → production → use → waste) to a circular economy model (extraction → production → use → recovery → production → use → ...), as outlined in the *Circular Economy Action Plan*.[57] The product framework is strengthened by the Ecodesign for Sustainable Products Regulation (ESPR),[58] which extends traditional ecodesign requirements beyond energy efficiency to include product durability, reparability and material circularity. The flow of secondary raw materials and control of waste exports are governed by the new Waste Shipment Regulation,[59] while demand for repairs and longer product lifecycles is supported by the Right to Repair Directive.[60] Particular importance is also attached to the Critical Raw Materials Act (CRMA)[61] which links resource security with targets for the processing and recovery of critical raw materials.

Position of Poland: the sector has recorded steady growth, reflecting market maturation and increasing specialization among Polish companies. The local nature of the industry limits the scale of international trade, which means that the trade balance typically remains relatively close to equilibrium. Between 2019 and 2024, the value of Polish exports increased from EUR 0.6 billion to EUR 0.9 billion. The overall RCA for the sector stands at 1.07.

Local content: the sector is shaped by the interaction of two business models: efficient and profitable domestic firms on the one hand, and rapidly expanding foreign-owned corporations on the other. This points to an ongoing process of market consolidation, with large international groups gaining market share through investments in large-scale processing facilities and the exploitation of economies of scale. Nevertheless, the sector's local content potential remains high, particularly in more advanced niches related to material recovery and specialized recycling.

56 Source: SpotData based on expert interviews.
57 *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: A New Circular Economy Action Plan for a Cleaner and More Competitive Europe* (COM(2020) 98, 11 March 2020).
58 *Regulation (EU) 2024/1781 of the European Parliament and of the Council of 13 June 2024 establishing a framework for the setting of ecodesign requirements for sustainable products, amending Directive (EU) 2020/1828 and Regulation (EU) 2023/1542, and repealing Directive 2009/125/EC.*
59 *Regulation (EU) 2024/1157 of the European Parliament and of the Council of 11 April 2024 on shipments of waste, amending Regulations (EU) No 1257/2013 and (EU) 2020/1056 and repealing Regulation (EC) No 1013/2006.*
60 *Directive (EU) 2024/1799 of the European Parliament and of the Council of 13 June 2024 on common rules promoting the repair of goods and amending Regulation (EU) 2017/2394 and Directives (EU) 2019/771 and (EU) 2020/1828* (OJ L 2024/1799, 10 July 2024).
61 *Regulation (EU) 2024/1252 of the European Parliament and of the Council of 11 April 2024 establishing a framework for ensuring a secure and sustainable supply of critical raw materials and amending Regulations (EU) No 168/2013, (EU) 2018/858, (EU) 2018/1724 and (EU) 2019/1020.*

Table 15. Characteristics of Polish-owned and foreign-owned firms

Characteristic	Polish-owned firms	Foreign-owned firms
Share of revenues	64.4%	35.6%
Revenue growth (2018–2023)	78.8%	135.5%
Net profitability	4.6%	3.3%

Source: SpotData.

Main value-chain segments:

- **plastic and packaging recycling** – despite the dominant position of foreign-owned companies, a large domestic company operates in Poland, demonstrating the ability to compete effectively with global corporations. Poland has achieved a high degree of specialization in recycled paper products,
- **specialized recovery and textiles** – a Polish company has come to dominate the used-clothing processing market. Poland is also home to a leading company in the rubber recovery industry,
- **metal and scrap recycling (traditional)** – Poland is a major player in the metal scrap trading industry. RCA indicators are particularly high for cadmium waste (11.98), chromium waste (6.67), alloy steel scrap (5.85) and magnesium scrap (3.36). Poland serves as a reservoir of raw materials for the European metallurgical industry, while the sector is based on privately owned Polish capital handling large volumes,
- **remanufacturing** – the highest-value-added segment, in which products are repaired rather than shredded. Foreign capital dominates this area (with one clear market leader), while Polish capital is present mainly in niche segments.

Table 16. Revealed comparative advantage indicators by value-chain element

Value chain element	Product name	RCA
Final product	Waste and scrap of cadmium	11.98
Final product	Waste and scrap of chromium	6.67
Final product	Waste and scrap of antimony	5.12
Final product	Waste and scrap of titanium	2.83
Final product	Waste and scrap of alloy steel	5.85
Final product	Waste and scrap of cast iron	3.53
Final product	Testliner paper ≤ 150 g/m²	1.46
Final product	Testliner paper > 150 g/m²	1.41
Final product	Fluting paper	1.29
Final product	Waste and scrap of magnesium	3.36
Final product	Hard zinc	1.35
Final product	Platinum catalysts (gauzes)	0.16
Intermediate product	Ashes and residues (of antimony, beryllium, cadmium)	2.45
Intermediate product	Aluminium scrap	1.76
Intermediate product	Cermet waste	1.69
Intermediate product	Aluminium turnings, filings and foil waste	0.62
Intermediate product	Aluminium waste	0.47
Intermediate product	Residues from copper production	0.23
Intermediate product	Waste molybdenum	0.04
Intermediate product	Waste tungsten	0.21
Intermediate product	Waste tantalum	0.05
Waste	Granulated slag	0.07
Waste	Lead waste	0.25
Waste	Waste tin	0.11
Waste	Bismuth waste (> 99.99%)	0.74

Source: SpotData.

Barriers to the development of local content:

- **market fragmentation** – this makes it more difficult for domestic companies to invest in modern sorting lines and chemical recycling facilities.

Development niches:

- **increasing value added in plastics** – Poland already has the capability to produce high-quality recyclates (rPET and rHDPE), but it should continue strengthening its position in this segment and move away from specialising in the sale of lower-value-added waste. Growing EU requirements regarding recycled content in new packaging (the Single-Use Plastics Directive – SUP Directive)[62] mean that demand in this market is expected to grow at a moderately rapid pace in the coming years.
- **syngas production technologies** – the conversion of difficult waste streams, for which conventional biogas is not a suitable alternative, into green gas (syngas) through on-site industrial installations. This is an area in which Polish companies are already implementing new technologies and can build energy sovereignty based on local resources.
- **battery and electronics recycling (urban mining)** – Poland has high revealed comparative advantage indicators in the trade of traditional metal scrap (cadmium – 11.98, chromium – 6.67, alloy steel – 5.85, magnesium – 3.36). However, these advantages disappear in the area of strategic raw materials used in modern technologies, which means that valuable urban deposits leave Poland without being processed. Ongoing investments may change this situation. The collection segment is already well developed, and material recovery is its natural continuation. Poland has the opportunity to become a leader of this transformation, as evidenced by the recognition of the construction of a domestic recovery complex under the IPCEI framework.
- **industrial recovery of rare and precious metals from electronics** – Poland still records low revealed comparative advantage indicators in this area (including the recycling of molybdenum, tantalum and processed catalysts), but new investments show that the segment is beginning to emerge as one of the country's growing niches.

Beyond reach by 2030:

- **global waste-management brands** – the municipal and industrial waste-services market is dominated by foreign-owned companies. Although domestic firms are expanding their fleets, there is little prospect of large-scale global expansion by Polish players in this segment.

Recommendations for public policy:

1. **Support for consolidation** – incentives for Polish recycling companies to merge into larger capital groups in order to compete with foreign firms for waste streams and contracts with major food and packaging producers.
2. **Investment in chemical recycling** – R&D grants for the development of chemical recycling technologies that can process difficult plastic waste streams and keep valuable materials within Poland.
3. **A second-life economy** – promotion of the remanufacturing and reuse sector through tax incentives (for example, lower VAT rates for repair services and refurbished products), supporting the most resource-efficient form of a circular economy.

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62 *Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment.*

14.
Raw materials and minerals

Role in the energy transition: critical raw materials and minerals form the foundation for the development of most clean technologies. The development of this segment improves supply-chain security through greater control over key material and resource inputs and is a prerequisite for the stability of cleantech manufacturing.

Market outlook: highly differentiated internally. According to the IEA,[63] average annual global demand growth between 2024 and 2030 may reach approximately 14% for lithium, 9.5% for graphite, 6% for cobalt, 5% for rare earth elements, 4.5% for nickel, and 2.6% for copper.

Position of the EU: despite significant growth in production, Europe remains highly dependent on external supplies, which is a key challenge for industrial sovereignty. The EU import-to-consumption ratio remains high at 77% (2024). Between 2019 and 2024, the value of production in the EU increased from EUR 23.0 billion to EUR 40.6 billion.

EU strategy: raw materials and minerals (particularly critical and strategic raw materials) are covered by a dedicated framework under the Critical Raw Materials Act (CRMA).[64] The regulation sets targets for developing domestic extraction, processing and recycling capacities by 2030, as well as targets related to creating demand for secondary raw materials. Earlier policy direction was established by the Critical Raw Materials Resilience communication[65] and the European Raw Materials Alliance (ERMA). The connection with the circular economy is reinforced by the Circular Economy Action Plan[66] and the Waste Shipment Regulation.[67] Implementation of the CRMA began with the selection of the first Strategic Projects in 2025 (47 projects within the EU and 13 outside the EU).

Position of Poland: the raw materials sector is growing more slowly than the median across cleantech industries (growth of 28.3% between 2019 and 2024, compared with 65.8% for all ten cleantech sectors). Polish-owned companies are losing market share to foreign firms – revenues of foreign-owned companies have grown faster, and their profitability is higher than that of domestic producers. Poland's competitive position in the raw materials sector is weakening. Only a limited number of categories exhibit high specialization, while a trade deficit remains visible. In absolute terms, exports increased from EUR 2.5 billion to EUR 3.2 billion. The overall RCA for the sector declined to 0.94, indicating a loss of export specialization.

Local content: moderate potential. The significant share of domestic firms indicates relatively strong roots in the metallurgical and recycling industries. Traditional processing activities (particularly copper and steel processing) continue to dominate the sector.

63 IEA, *Global Critical Minerals Outlook 2025*, 2025.
64 *Regulation (EU) 2024/1252 of the European Parliament and of the Council of 11 April 2024 establishing a framework for ensuring a secure and sustainable supply of critical raw materials and amending Regulations (EU) No 168/2013, (EU) 2018/858, (EU) 2018/1724 and (EU) 2019/1020.*
65 *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Critical Raw Materials Resilience – Charting a Path towards Greater Security and Sustainability* (COM(2020) 474, 3 September 2020).
66 *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: A New Circular Economy Action Plan for a Cleaner and More Competitive Europe* (COM(2020) 98, 11 March 2020).
67 *Regulation (EU) 2024/1157 of the European Parliament and of the Council of 11 April 2024 on shipments of waste, amending Regulations (EU) No 1257/2013 and (EU) 2020/1056 and repealing Regulation (EC) No 1013/2006.*

Table 17. Characteristics of Polish-owned and foreign-owned firms

Characteristic	Polish-owned firms	Foreign-owned firms
Share of revenues	43.5%	56.5%
Revenue growth (2018–2023)	16.0%	53.8%
Net profitability	2.7%	3.2%
Number of patents (2001–2025)	39	23

Source: SpotData.

Main value-chain segments:

- **Steel and specialist metals processing** – this is the strongest link in Polish industry. Poland is a European leader in the production of silicon electrical steel, which is essential for the manufacture of transformers and electric motors. The country also holds a strong position in aluminium alloys and alloy-steel scrap, both of which are critical for the wind-energy and automotive industries.
- **Chemical raw materials for batteries and photovoltaics** – in this segment, Poland has a high degree of specialization in carbonates used, among other applications, in electrolytes and photovoltaic glass. In the case of key battery metals in their primary form (lithium, cobalt and nickel), however, the country is entirely dependent on imports.
- **Recycling and urban mining** – this is a strategic segment that combines traditional industry players with new technology leaders. Alongside global corporations, Polish companies play a key role. One of Europe's largest facilities for recovering lithium, cobalt and nickel from end-of-life batteries, currently being developed under an IPCEI project, may shift Poland from the position of a raw-material importer to that of a supplier of secondary raw materials.

Table 18. Revealed comparative advantage indicators by value-chain element

Product name	Key applications	RCA
Carbonates	Photovoltaics	17.55
Electrical steel	Electromobility, grids and transformers	12.80
Alloy-steel scrap	Wind, electromobility	5.85
Ferroalloys (manganese)	Wind	5.02
Refined copper and copper alloys	Electromobility	4.50
Ferroalloys	Photovoltaics	3.83
Cast-iron scrap	Wind, electromobility	3.53
Biomass	Power and heat	3.08
Unwrought aluminium alloys	Wind, electromobility, photovoltaics	2.40
Synthetic graphite	Batteries	1.04
Hydrogen	Hydrogen	0.92
Copper waste	Grids (cables), wind	0.90
Nickel sulphates	Batteries	0.73
Ferrovanadium	Storage	0.61
Lithium (hydroxide/oxide)	Batteries	0.50
Glass fibre rovings	Wind	0.11
Cobalt oxides	Batteries	0.08
Carbon fibres	Wind, hydrogen	0.04
Rare earth metals (cerium, lanthanum)	Electromobility, wind	0.03
Lithium	Batteries	0.02
Silicon (polysilicon) > 99.99%	Photovoltaics	0.00

Source: SpotData.

Barriers to the development of local content:

- **capital and investment asymmetry** – foreign companies are developing much faster than domestic firms, creating a risk that the most promising recycling and processing segments will be taken over by firms with greater investment capacity,
- **declining competitive advantage** – at the level of the sector as a whole, Poland has lost its overall export specialization, while the growing trade deficit indicates that domestic industry is not yet keeping pace with the growth in demand for raw materials and semi-finished products required for the transition.

Development niches:

Poland's strength does not lie in the extraction of primary raw materials from the ground, but in their processing and recovery from end-of-life products. The Polish industrial base has the potential to become a leader in so-called urban mining, using its strong metallurgical base to close material loops in the battery and renewable-energy sectors. Possible development pathways include:

- **creating a recycling hub based on Europe's battery manufacturing centre** – Poland's existing advantage in the battery sector should be leveraged to develop the processing of production waste and end-of-life battery cells. New investments indicate that Polish companies could become pioneers in the recovery of critical raw materials,
- **low-emission steel and copper** – growing demand for copper (essential for electricity grids and wind turbines) positions Poland as a strategic supplier for Europe's energy transition. At the same time, Poland's strong position in silicon electrical steel (essential for electromobility and the smart-grid sector) is currently its most important specialization. However, the country's potential extends further and includes better utilization of steel scrap, reducing the carbon intensity of domestic metallurgy, and expanding processing based on electric arc furnaces.

Beyond reach by 2030:

- **domestic extraction of most critical raw materials** – this implies continued dependence on imports of concentrates and semi-finished products, which are only processed domestically at later stages of the value chain,
- **domestic production of high-purity polysilicon for photovoltaics** – this remains a bottleneck for the development of the European photovoltaic industry. Technological progress in large-scale secondary silicon production is also unlikely to provide a solution within the next five years.

Recommendations for public policy:

1. **Recycling as the foundation of sovereignty** – critical raw-material recovery facilities should be recognised as strategic infrastructure. Capital support should be provided to Polish companies investing in urban-mining technologies in order to retain the value added generated through metal recovery within the country.
2. **Specialization in steel production for the energy sector** – support should be directed towards modernising the steel industry to produce low-emission electrical and structural steel, for which demand in the wind-energy and grid sectors is expected to grow.
3. **Integration of the copper value chain** – promote the use of Polish copper in the domestic production of cables and electric motors in order to maximise value capture at every stage of processing.

15.
Industrial low-emission technologies

Role in the energy transition: these are technologies used to reduce greenhouse-gas emissions across industry and the energy sector more broadly, rather than being limited strictly to zero-emission technologies. The category therefore also includes transitional solutions that improve energy efficiency and reduce emissions. The development of this segment improves economic and resource security through a greater domestic supply of key intermediate products and increased use of secondary raw materials.

Market outlook: the sector encompasses a broad range of technologies required for the decarbonization of industry and distributed energy systems: from turbines and generators, through industrial filtration systems, to emerging hydrogen technologies, including electrolyzers, components and implementation solutions for industrial decarbonization. Estimated global growth is approximately 8–12% annually through 2030.[68]

Position of the EU: production is growing steadily, driven by the need to modernize industrial assets and comply with the requirements of the Industrial Emissions Directive (IED).[69] The market exhibits very high import intensity (145.2% in 2024), indicating that Europe relies heavily on imported components and equipment for building its industrial low-emission infrastructure. Between 2019 and 2024, the value of EU production increased from EUR 6.2 billion to EUR 8.7 billion.

EU strategy: the category is not covered by a dedicated sector-specific act, but industrial low-emission technologies are at the centre of the EU's competitiveness and industrial decarbonization agenda under the Clean Industrial Deal.[70] The Net-Zero Industry Act (NZIA)[71] provides the framework for scaling up European production of net-zero technologies and related components. For process industries and emissions-intensive sectors, the Industrial Carbon Management Strategy[72] and the revised Industrial Emissions Directive (IED)[73] are also key instruments, strengthening environmental standards, resource efficiency and transformation requirements for industrial installations. Access to materials and secondary raw materials is further supported by the Critical Raw Materials Act (CRMA).[74] Circular Economy Action Plan[75] and the Waste Shipment Regulation[76] are particularly important for segments based on metals, scrap and industrial intermediate products.

68 Source: SpotData.
69 Source: SpotData based on Eurostat data for import intensity; regulatory dimension: Directive 2010/75/EU of the European Parliament *and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control).*
70 *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Clean Industrial Deal – A Joint Roadmap for Competitiveness and Decarbonisation* (COM(2025) 85, 26 February 2025).
71 *Regulation (EU) 2024/1735 of the European Parliament and of the Council of 13 June 2024 establishing a framework of measures for strengthening Europe's net-zero technology manufacturing ecosystem and amending Regulation (EU) 2018/1724.*
72 *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Towards an Ambitious Industrial Carbon Management Strategy for the EU* (COM(2024) 62, 6 February 2024).
73 *Directive (EU) 2024/1785 of the European Parliament and of the Council of 24 April 2024 amending Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control) and Council Directive 1999/31/EC on the landfill of waste.*
74 *Regulation (EU) 2024/1252 of the European Parliament and of the Council of 11 April 2024 establishing a framework for ensuring a secure and sustainable supply of critical raw materials and amending Regulations (EU) No 168/2013, (EU) 2018/858, (EU) 2018/1724 and (EU) 2019/1020.*
75 *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: A New Circular Economy Action Plan for a Cleaner and More Competitive Europe (COM(2020) 98, 11 March 2020), and Regulation (EU) 2024/1781 of the European Parliament and of the Council of 13 June 2024 establishing a framework for the setting of ecodesign requirements for sustainable products, amending Directive (EU) 2020/1828 and Regulation (EU) 2023/1542, and repealing Directive 2009/125/EC.*
76 *Regulation (EU) 2024/1157 of the European Parliament and of the Council of 11 April 2024 on shipments of waste, amending Regulations (EU) No 1257/2013 and (EU) 2020/1056 and repealing Regulation (EC) No 1013/2006.*

Position of Poland: the sector is developing more slowly than other cleantech industries. Between 2019 and 2024, Polish exports increased by 27.1%, from EUR 1.37 billion to EUR 1.74 billion. This result is significantly below the median for clean technologies (65.8%), suggesting that the industry is in a phase of maturity or stabilisation rather than the exponential growth characteristic of batteries or photovoltaics. The overall RCA for the sector stands at 1.06, indicating that export specialisation has been maintained, although it is weaker than it was a few years ago.

Local content: the share of Polish capital in sector revenues is low, but domestic companies are recording strong revenue growth and good profitability. The sector's potential, which competes through engineering quality and service rather than cost alone, is based more on specialised niches than on the scale of the overall market.

Table 19. Characteristics of Polish-owned and foreign-owned firms

Characteristic	Polish-owned firms	Foreign-owned firms
Share of revenues	9.2%	90.8%
Revenue growth (2018–2023)	37.9%	n/a
Net profitability	8.2%	8.2%

Source: SpotData.

Main value-chain segments:

- **distributed energy and cogeneration (small turbines)** – Poland records a strong export advantage in low-capacity gas turbines (<5,000 kW). Manufacturers of power generators, power-supply systems and cogeneration units also perform well, as do specialised service providers operating in these segments,
- **air-pollution control and filtration technologies** – a strong but less visible group consists of manufacturers of industrial filtration systems, which are essential for meeting emission standards. Existing companies have created a dense ecosystem of suppliers of air and liquid filters. Nevertheless, the market remains saturated with imported products, and Polish firms continue to compete for position in the domestic market,
- **hydrogen technologies and future-oriented solutions (start-ups)** – these remain at a very early R&D stage and are recording losses, which is typical for the development phase of deep-tech technologies. Their presence nevertheless signals ambitions to participate in future supply chains.

Table 20. Revealed comparative advantage indicators by value-chain element

Value-chain element	Product name	RCA
Final product	Gas turbines ≤ 5 MW	31.44
Final product	Gas turbines > 50 MW	0.08
Final product	Gas turbines 5–20 MW	0.01
Final product	Catalysts and particulate filters	0.58
Component	Steam and hydro turbine parts	5.34
Component	Gas turbine parts	0.37
Component	Magnet parts, electromagnetic couplings	1.64
Component	Electromagnets and magnetic chucks	0.96
Component	Electromagnetic clutches and brakes	0.41
Component	Linear hydraulic actuators	0.44
Component	Heat-treatment equipment	0.6
Component	Gas-filtering equipment	0.47
Component	Beam furnaces	0.93
Raw material	Ion exchangers (polymers)	0.04
Raw material	Alloy steel scrap	5.85
Raw material	Cast-iron scrap	3.53

Source: SpotData.

Barriers to the development of local content:

- **fragmented capital base** – the Polish sector consists primarily of small and medium-sized enterprises (with revenues in the range of PLN 20–80 million), which may face difficulties in financing costly R&D work on new technologies.

Development niches:

- **small-scale cogeneration (CHP)** – in response to rising energy costs, an increasing number of Polish industrial facilities are investing in their own energy sources. Manufacturers of such equipment are natural beneficiaries of this trend. Poland's specialisation may also enable expansion into other markets, including Ukraine and Romania,
- **servicing and modernisation** – Poland has a strong base in steam and hydro turbine parts. Existing companies can serve as maintenance and service hubs for ageing energy infrastructure across Central and Eastern Europe.

Beyond reach by 2030:

- **large gas turbines (above 50 MW)** – this will continue to make large-scale power generation dependent on foreign suppliers, even if only during the transition period,
- **scalable hydrogen technologies** – despite the specific role hydrogen should play in a decarbonised economy (where more efficient methods, such as electrification, are not feasible) and the presence of ambitious companies, Poland does not manufacture electrolyzers on an industrial scale that would allow it to compete with Western producers.

Recommendations for public policy:

1. **Support for cogeneration** – promoting the installation of small CHP systems in industry and district heating, while giving preference to domestic products, would create demand for goods manufactured by Polish producers.
2. **Incubation of hydrogen technologies** – launch grant competitions that enable companies to move from the prototype stage to serial production.
3. **Filtration cluster** – support international expansion for manufacturers of industrial filters, which have the potential to become suppliers to the European processing industry.

16. Summary

Our analysis indicates that Poland's potential in clean technologies is significant, but unevenly distributed. In some industries, domestic firms hold a strong position and are capable of further scaling, while in others the rational level of ambition is to secure strategic market niches where Poland already possesses the necessary capabilities and resources. This makes it possible to identify where the energy transition can become a driver of durable industrial advantages and where a more cautious and selective approach is required. On this basis, a number of general conclusions and principles can be formulated to guide the development of Polish industrial policy.

1. **Clean technologies mean greater security and sovereignty**
   Dependence on external fuel supplies is costly, even when those supplies come from politically stable and commercially predictable countries. For this reason, Poland should ensure broad domestic capabilities for cleantech production in the future. National security considerations also provide a rationale for applying local content requirements in public investments.

2. **Technological security also includes the digital layer**
   Digital components, control systems and data-processing capabilities are becoming increasingly important in clean technologies. Industrial policy should therefore treat digital security as an integral part of technological security by supporting solutions that meet high standards of cybersecurity, interoperability and data control, particularly in critical infrastructure sectors.

3. **Local content understood as knowledge creation in Poland**
   The most important criterion for recognising industries and technologies as strategically important should be whether Poland possesses the capability to generate knowledge and technology within them. Intellectual property should be one of the key criteria for defining local content. One possible approach would be to make public grants conditional on retaining in Poland the intellectual property created under a given project. The same principle should apply to public procurement: major projects should leave behind cooperation with scientific institutions and implementation capabilities within the country, rather than only final assembly activities.

4. **Foreign investment beyond assembly operations**
   When attracting foreign investment, emphasis should be placed on generating value added within Poland rather than merely assembling imported components. Foreign companies carrying out contracts related to public investments in Poland should receive greater incentives the more they rely on domestic knowledge, technologies and expertise.

5. **Reassessing support for research and development**
   Support for research and development should be more strongly embedded in the country's development strategy and focused to a greater extent on technologies critical to national security. Administrative processes should be simplified, excessive bureaucracy reduced, and expert capacity strengthened. Public funding should more often be used to solve specific technological and implementation challenges faced by industries and to support areas where there is a realistic opportunity to build durable competitive advantages and achieve global scalability.

6. **Certification and standardisation as a condition for growth**
   The cost and complexity of certification are among the main barriers to the development of Polish companies. The state should support the financing of certification processes, adaptation of products to international standards and the development of competencies in this area. In many industries, compliance with standards is the decisive factor determining entry into more advanced market segments and enabling export expansion.

7. **Industrial policy tailored to the starting point**
   Over the coming decade, efforts should focus on strengthening the existing competitive advantages of domestic firms. In the longer term, Poland should seek to facilitate the diffusion of more advanced technologies from foreign investors operating in the country. To make this possible, foundations must be laid today by building technological capabilities within the public sector, providing predictable energy-transition strategies and strengthening financing for innovative enterprises.

8. **Regulatory predictability and continuity of public instruments**
   Industrial policy requires a stable regulatory environment. This applies both to support programmes and to tariff, auction and investment frameworks. Companies are able to scale production and undertake long-term investments only when they operate in a predictable market environment with a clear timetable for regulatory changes.

9. **Export support as a tool for achieving scale**
   Industrial policy should support not only the establishment of production within Poland but also the international expansion of Polish companies. This includes trade finance, export guarantees, participation in trade fairs and business missions, and support for entry into new markets. Scale in international sales helps reduce unit costs, strengthens companies' positions within supply chains and reinforces competitive advantages.

10. **Stimulating competition in the private sector**
    Government support should stimulate competition between companies. It is important not only to support the strongest firms but also to allow the weakest to exit the market. Situations in which public contracts within a given area are awarded to a single company should also be avoided. Such arrangements weaken competitive pressure and increase the risk of higher costs and lower efficiency in public procurement.

11. **Building credibility through quick wins**
    It is worth selecting areas and initiatives where credible and visible results can be achieved within a single electoral cycle, thereby building confidence in the effectiveness of public policy. This does not mean abandoning long-term objectives, but rather starting with projects that are institutionally feasible and create a foundation for more complex actions. Given the siloed nature of public administration, efforts should focus on initiatives that can be implemented within a single institution. This helps overcome the challenge of coordination across ministries. Where success depends on sustained cooperation among multiple actors, permanent platforms for collaboration should be established between public administration, business, academia and financial institutions. Their role should be to jointly identify barriers, agree on priorities and accelerate implementation.

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