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GREENING ROMANIA'S INDUSTRY: POLICY RECOMMENDATIONS FOR DECARBONIZATION, COMPETITIVENESS, AND CLIMATE RESILIENCE

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Abbreviations and Acronyms

AI	Artificial intelligence
ANRE	Romanian Energy Regulatory Authority
BESS	Battery energy storage systems
CBR	Cash burn rate
CCS	Carbon capture and storage
CCUS	Carbon capture, utilization, and storage
CfD	contract-for-difference
CEE	Central and Eastern Europe
CISC	Inter-Ministerial Committee on Climate Change
DG REGIO	European Commission's Directorate-General for Regional and Urban Policy
EDIH	European Digital Innovation Hub
EPR	Extended producer responsibility
EU	European Union
EV	electric vehicle
FAT	Firm-level Adoption of Technology
FDI	foreign direct investment
GDP	Gross domestic product
GHG	Greenhouse gas
GRIN	Supporting Romania's Green Industrial Plan and Strengthening Coordination for Climate Change Initiatives (World Bank Reimbursable Advisory Services project)
GVC	Global value chain
GW	gigawatt
KF	Key finding
MIS	Management information system
MSMEs	Micro-, small and medium-sized enterprises
MW	Megawatt
NACE	Statistical Classification of Economic Activities in the European Community (from the French *Nomenclature statistique des activités économiques dans la Communauté européenne*)
NRRP	National Recovery and Resilience Plan
NZIA	Net-Zero Industry Act
PCG	Partial Credit Guarantees
PPWR	Packaging and Packaging Waste Regulation
PV	photovoltaic
R&D	Research and development

R&I	Research and innovation
RAS	Reimbursable Advisory Services
SME	Small and medium-sized enterprise
STEP	Strategic Technologies for Europe Platform
SUP	Single-use plastic

Executive summary

Romania stands at a pivotal moment in its economic development: As the European Union (EU) accelerates its green industrial transition, timely investments and reforms can boost Romanian firms' chances of seizing the competitive opportunities this creates. The Government of Romania, seeking to strengthen its approach to green industrial transformation, requested the support of the World Bank to obtain evidence-based analysis and actionable policy recommendations. These will help inform the design and implementation of smart industrial policy packages that support the private sector through the green transition.

This final report is organized around three interconnected pillars—industry decarbonization, green competitiveness, and private sector adaptation to physical climate risks. Together, these pillars capture the full scope of the green transition challenge — reducing the carbon intensity of existing industries, building new competitive positions in emerging green value chains, and strengthening Romanian firms' resilience to the growing physical impacts of climate change. Several of the key constraints highlighted in the report, such as technology adoption, managerial capabilities, skills, or innovation ecosystems, are relevant across pillars and addressing them can support the private sector in mitigating the risks and seizing the opportunities of the green transition.

Pillar 1: Industry Decarbonization

Key messages:

- **Emissions are heavily concentrated in a small group of sectors and firms, providing an opportunity for targeted interventions.**
- **Firms are not sufficiently adopting technologies that can close efficiency gaps due to access to finance gaps, limited information, and regulation failures.**
- **There is limited public support for advanced technological pathways, such as CCS or biomethane, which are critical in hard-to-abate sectors.**

A small group of sectors in Romania present outsized decarbonization challenges. A decomposition analysis found that Romania's private sector emissions (excluding extractives and energy sector) are highly concentrated. Seventy-eight percent of CO_2 emissions in manufacturing, construction, and services originate from just ten NACE[1]-2 level sectors, which account for only 39 percent of total employment. Moreover, just ten companies producing cement, lime, and plaster employing approximately 3,000 workers emit more CO2 than the entire wholesale and retail trade sector, which employs more than half of a million people.

This concentration can be an opportunity, as targeted technological and managerial interventions in a relatively small number of sectors can deliver outsized benefits. Analysis

[1] NACE (from the French Nomenclature statistique des activités économiques dans la Communauté européenne) is the European Union's statistical classification of economic activities. NACE codes are used to classify firms according to their primary economic activity.

using CO_2 data showed that if all firms had the same level of emissions intensity as the median firm of the same size in the same sector, Romania could reduce total private sector CO_2 emissions by 43 percent, with most of the gains coming from the top polluting sectors. Another simulation also showed that closing the technology adoption gap in the wider economy can yield significant gains in energy efficiency (EE) and productivity—if, for example, below-median firms caught up to the sector median level of digitalization, their productivity could increase by up to 15 percent and energy efficiency by up to 13 percent.

However, a large representative survey of 1,500 companies found significant gaps in the adoption of both digital and green technologies. The survey found that even though adoption of digital and green technologies is widespread, it is concentrated in less sophisticated technologies and basic management practices. While basic green technologies generate modest efficiency gains, more advanced tools are strongly associated with both energy efficiency and productivity. Romanian firms have embraced basic digital tools, but remain behind the technological frontier, and primarily rely on more basic technologies even when more advanced technologies are at their disposal. The study found that broad-based digitalization—not only green-specific technologies—can serve as a meaningful pathway to reducing firms' carbon footprint.

At the same time, the concentration of emissions in a few sectors also highlights the limits of firm-level efficiency improvements. While closing technology and management gaps can deliver large emissions savings, in hard-to-abate sectors such as cement and chemicals even the median firm remains relatively emissions-intensive because production processes are structurally carbon-intensive. Further reductions beyond within-sector catch-up would therefore require more advanced technological pathways, such as carbon capture and storage (CCS), hydrogen, or biomethane. These technologies remain commercially immature, and some of them, including CCS and biomethane, currently lack dedicated policy support in Romania.

In addition, while access to finance has been shown to increase the adoption of green technologies, the analysis finds barriers to finance on both the supply and demand sides. Firms in Romania report financial constraints as the key barrier to digital and green technology upgrading, with 37 percent of firms citing them as the main obstacle to technology adoption. These constraints are compounded by Romania's shallow financial intermediation: the country has the lowest level of financial intermediation in the EU, a micro-, small and medium-sized enterprise (MSME) financing gap estimated at 26 percent of gross domestic product (GDP), and loan rejection rates of 22.5 percent, nearly three times the Europe and Central Asia average. Private lending for energy efficiency also remains limited. A survey of Romanian banks found that energy efficiency loans account for only 2.2 percent of total lending to non-financial firms, equivalent to €0.7 billion out of €32.6 billion in the reporting sample. Lending is particularly weak in industry, where energy efficiency loans represent only 1.3 percent of total industrial lending.

However, finance is only one part of the problem: weak demand, limited information, and insufficient incentives also hold back technology upgrading. Many firms overestimate their own technological level, a significant share report no perceived need to adopt, and investment remains

largely reactive rather than driven by competitive ambition. Advisory services could stimulate firm demand for financing, as well as access to information and awareness about the benefits of technology upgrading, yet they are offered by only 21 percent of banks. Managerial quality is also key for maximizing the benefits of technology adoption, as both managers' and workers' capabilities matter for the decision to adopt new technologies and for getting the most out of them once in place. Yet very few firms identify capability gaps as a barrier.

The analysis also found evidence of regulatory failures that contribute to resources in Romania flowing toward less energy-efficient firms. Those include challenges with translating EU directives into clear, context-specific national regulations aligned with market needs, as well as energy cost subsidies that shield large incumbent emitters from competitive pressure. Mandates and minimum energy performance standards have been in place in Romania and could incentivize upgrades when energy costs are low, but their implementation remains fragmented.

Finally, decarbonization at the firm level can be increased not only through more efficient energy use but also by using less-polluting energy sources. Romanian firms do not seem to be switching to green energy sources, and this dependence appears to be at least partly driven by the high short-term costs of fuel substitution. Fully decarbonizing the grid would support this objective, but it would not be enough on its own, as many firms also generate emissions directly from fuels and processes used on site. In the near term, solar energy for industrial self-consumption is therefore a promising complementary option for Romanian firms helping reduce electricity costs and lower part of their emissions. However, investment is constrained by limited incentives and weak targeting of the portfolio mix of public financing instruments.

Pillar 2: Green Competitiveness

Key messages:

- **Romanian firms can seize market opportunities in green value chain segments, such as stationary energy storage, wind energy conversion systems, and sustainable high-volume recycling.**
- **An underperforming innovation ecosystem is a critical horizontal barrier to green competitiveness.**
- **A significant skills gap in competencies that are increasingly in demand in green value chains limits access to opportunities.**

Romanian firms can leverage global industrial decarbonization efforts to expand their participation in global clean-technology value chains. By 2030, technology-related exports in key green sectors — including electric vehicle (EV) batteries, wind energy components, solar, and heat pumps — could triple or quadruple from current levels, provided the right enabling conditions are in place. The Romanian economy is in a strong position to build on existing capabilities and capitalize on opportunities to participate in new green markets. The Government of Romania chose three sectors from a shortlist based on desk research and expert consultations, reflecting each sector's green economy potential and relevance to Romania's industrial base. Rapid sector assessments of

the three selected sectors identified promising opportunities, but these should be understood as illustrative examples rather than an exhaustive prioritization of value chains for public support.

The sector assessments of the sample of three sectors reveal that the most feasible near-term opportunities are not necessarily in upstream, capital-intensive manufacturing. In large rechargeable batteries, manufacturing cells for electric vehicles offers limited near-term potential because the global market is concentrated, capital requirements are high, and global overcapacity is pushing prices down. In wind energy, Romania is also less well positioned to manufacture large structural components, such as turbine blades, which require proximity to ports and robust transport infrastructure. In plastics and packaging, upstream production offers more limited opportunities due to large capital requirements, global oversupply, and high energy costs.

The more realistic opportunities are in integration, components, services, and compliance-driven segments where Romania can build on its existing industrial base. In stationary energy storage, these include system integration, power electronics, structural components, and long-term maintenance. In wind energy, opportunities include components and services for the electrical and civil infrastructure that connects turbines to the grid, such as substations, cabling, and installation services. In plastics and packaging, incoming EU packaging regulations create a specific window for sustainable high-volume recyclable packaging, where Romania can leverage existing industrial capacity, competitive labor costs, and high-purity recycling infrastructure.

However, several challenges currently limit Romanian firms' ability to capitalize on the specific market opportunities identified in the analysis of this sample of sectors. In battery storage, commercial banks lack the experience to assess the revenue models for energy storage projects, making financing terms prohibitive for viable projects. Grid connection bottlenecks and slow permitting processes add uncertainty and cost to project execution, raising perceived risk. In wind energy, the predictability of project execution is undermined by convoluted permitting processes, grid connection requirements that are subject to change, and unclear allocation of connection risk between developers and system operators. In addition, demand remains unpredictable and insufficient for domestic manufacturers to justify investment in upgrading and certification. In plastic packaging, non-compliant imports undercut the business case for domestic compliant production, while the lack of domestic accredited testing and validation facilities increase firm costs and cause delays.

Beyond the sector-specific constraints identified above, weak innovation fundamentals are a horizontal barrier to Romania's green competitiveness. The country currently has the lowest rate of business research and development (R&D) investment in the European Union, and environmental regulations play virtually no role in driving firm-level innovation. Without stronger incentives for R&D and technology adoption, green innovation is unlikely to scale, since it remains only a small subset of Romania's already limited innovation activity. This puts the country at risk of remaining a low-value-added participant in value chains, including green value chains, rather than becoming a competitive supplier.

Skills shortages are another horizontal constraint. Green jobs require higher levels of technical and problem-solving skills that are already in short supply in Romania. For example, the battery sector assessment identified shortages in technical disciplines such as energy management systems and battery performance analytics. At the same time, Romania is not yet using demand-side policies, such as environmental standards and green procurement, strongly enough to create markets for green products and services. Despite Romania's potential for green value-chain integration, the existing policy mix is not funded at the scale or structured in the way needed to address these cross-cutting barriers.

Pillar 3: Private Sector Adaptation to Physical Climate Risks

Key messages:

- **Despite significant climate risk, firms in Romania do not invest sufficiently in climate adaptation.**
- **The current approach to climate adaptation finance is reactive, while a shift to ex-ante resilience instruments is more fiscally sustainable.**

Romania is the most climate-vulnerable country among its regional peers, with flooding posing the dominant hazard to the private sector. Flooding can cause an estimated €156 million annually in business interruptions, of which 37 percent is directly attributable to climate change intensification. Stress-testing of approximately 800,000 Romanian firms against flood scenarios reveals that a 1-in-100-year flood event could push 23,000 currently profitable firms into financial distress (a moderate but meaningful 4.4 percent decline), threatening more than 25,000 jobs and significant economic output. The burden of such a climate event would fall disproportionately on economically lagging regions and vulnerable sectors.

Despite the high climate exposure, Romanian firms show limited awareness of climate risk and low investment in climate adaptation measures. Only 23 percent of Romanians consider climate change a "very serious" issue, roughly half the EU average, and fewer than 25 percent of business assets are covered by any form of climate insurance, which is considered to be too expensive or inaccessible by half of firms. Just 39 percent of small and medium-sized enterprises (SMEs) have undertaken any adaptation measures, compared to 59 percent of large firms. While overall green lending has increased from less than 0.5 percent in 2022 to 3 percent in 2024, Romanian banks have seen limited uptake in loans explicitly dedicated to climate adaptation projects

The current gap in climate adaptation financing for the private sector can be addressed with a layered approach that includes ex-ante resilience instruments. An assessment of Romania's national green transition policy portfolio found that there are no instruments dedicated to climate adaptation for the private sector. The current approach remains focused on post-disaster relief rather than proactive resilience-building. This policy void leaves Romanian firms exposed to escalating physical risks with no structured support for preparedness. Modeling estimates that the total funding

requirements to help firms overcome short-term liquidity distress is approximately €1.8 billion in a 1-in-100-year scenario. A shift towards ex-ante resilience instruments is not only feasible but fiscally responsible, with contingent costs of 10 to 25 percent of equivalent direct relief expenditure. A layered approach combining credit guarantees, expanded insurance coverage, and business continuity requirements could shift Romania toward a fiscally sustainable resilience model built on existing institutions.

Cross-Cutting: Governance

Across all three pillars, the analysis identifies several systemic governance challenges that constrain Romania's ability to deliver results. Romania's green transition governance is increasingly complex and multi-layer, with resulting challenges related to fragmentation and inter-agency coordination. Governance is fragmented across multiple ministries, with the Ministry of Energy managing over 60 percent of green funds without the support of specialized implementing agencies that can support the separation of strategic and operational functions. Administrative deficiencies, such as lack of shared digital infrastructure, irregular funding calls, cumbersome application procedures, fragmented access to information, and others, result in implementation delays and lack of predictability. As of December 2024, disbursement across the €10 billion green policy portfolio stood at less than 5 percent, reflecting low implementation capacity.

Key Recommendations

The analyses conducted under the Reimbursable Advisory Services (RAS) Agreement on *Supporting Romania's Green Industrial Plan and Strengthening Coordination for Climate Change Initiatives* (GRIN) demonstrate that Romania faces both an urgent need and the latent potential to accelerate its green industrial transition; it also points to critical gaps that need to be addressed for this to happen. The recommendations below, derived from the analysis above, provide a structured pathway for the Government of Romania to translate ambition into results. They can be integrated and incorporated into Romania's various policy documents on industrial policy and the green transition.

Table 1 Key short-term recommendations by area

Area	Short-term actions	Responsible party	Priority (indicative)
Strategy and finance	**Development of sector-specific decarbonization roadmaps** for the **most carbon-intensive industries**, translating national green targets into technology-specific investment pathways, sequenced project pipelines, and clearly assigned responsibilities across financing, regulation, infrastructure, and technical assistance. ***Pillar: Decarbonization***	Ministry of Energy / Ministry of Economy (MEDAT)	Short-Term

	Rebalancing the green transition finance portfolio away from grant support for commercially viable investments toward a more selective use of public finance, with grants focused on feasibility studies, transformation planning, and early adoption incentives, and larger capital investments supported through guarantees, concessional loans, partial grants, and co-investment instruments. ***Pillar: Cross-cutting***	Ministry of Investments and European Projects (MIPE) / Investment and Development Bank (BID) / Ministry of Energy	Short-Term
	Establishment of **blended finance and risk-sharing instruments for hard-to-abate sectors and emerging green value-chain investments** where long payback periods, technology risks, or coordination failures prevent otherwise viable projects from reaching financial close. ***Pillar: Decarbonization***	Investment and Development Bank (BID) / Ministry of Energy / MIPE	Medium/ Long-term
	Development of Parcial Credit Guarantees (PCGs) for climate adaptation as part of a proactive private-sector resilience framework, enabling firms to invest in climate-risk reduction before climate shocks occur. ***Pillar: Adaptation***	National Credit Guarantee Fund for SMEs (FNGCIMM) / PAID Romania / MMAP	Medium-Term
	Development of targeted supplier-development and investment-readiness services for SMEs and mid-cap firms, covering firm-level diagnostics, buyer linkages, export-readiness support, and project preparation. Where off-takers are multinational or regional companies, these services should be explicitly linked to export development, while also helping firms access certification and quality assurance needed to qualify for green value chains. ***Pillar: Competitiveness***	Agency for SMEs and Entrepreneurship (AIMMAIPE) / MEDAT / Romanian Standardization Association (ASRO)	Medium/ Long-term
Regulations and procurement	**Review of energy price subsidies** to ensure that public policy does not protect inefficient incumbent emitters or weaken the market reallocation toward more productive and lower-emission firms. ***Pillar: Decarbonization***	Ministry of Energy / Romanian Energy Regulatory Authority (ANRE)	Short-term
	Establishment of sector-specific regulatory and market-creation packages for priority green value chains, including storage tariff reform and procurement planning for BESS, auction predictability and delivery discipline for wind, and PPWR/EPR implementation for circular packaging	ANRE / Ministry of Energy	Medium/ Long-term

	Pillar: Competitiveness		
	Operationalization of Green Public Procurement as a demand-creation instrument, moving from voluntary guidance to enforceable requirements in selected high-impact purchasing categories, supported by clear supplier standards and national implementation oversight. ***Pillar: Competitiveness***	National Agency for Public Procurement (ANAP) / Ministry of Environment, Water and Forests (MMAP)	Short-term
Governance and data infrastructure	**Creation of a national one-stop-shop for green transition support**, consolidating information on financing instruments, advisory services, and application procedures into a single access point for firms, utilizing existing market programs, such as energy audit and EMS drives, and regional delivery channels to reach SMEs outside major economic centers. ***Pillar: Decarbonization***	General Secretariat of the Government (GSG) / Ministry of Energy / MIPE	Medium-Term
	Creation of dedicated implementing agencies for priority green transition instruments or repurposing existing bodies, such as the SME Agency or Innovation Agency, with clearly defined mandates, protected multi-year operational budgets, and specialized technical staff to separate strategic policy direction from day-to-day program delivery and improve implementation performance. ***Pillar: Cross-cutting***	GSG / AIMMAIPE / Innovation Agency (planned)	Medium-Term
	Publication of a multi-year green transition funding calendar across major public financing instruments, specifying indicative call dates, budgets, and focus areas to improve investment planning for firms, banks, and implementing agencies. ***Pillar: Cross-cutting***	MIPE / Ministry of Energy	Short-term
	Introduction of a shared digital monitoring and management system integrated with EU funding requirements, with minimum data standards and dedicated data stewards to replace fragmented manual reporting and enable consistent tracking of applications, disbursements, beneficiaries, and outputs across the green transition portfolio. ***Pillar: Cross-cutting***	Ministry of Research, Innovation and Digitalization (MCID), MIPE, Authority for Digitalization of Romania (ADR)	Medium-Term

Note: BESS = battery energy storage systems; EPR = extended producer responsibility; PCGs = partial credit guarantees; PPWR = Packaging and Packaging Waste Regulation; SMEs = small and medium-sized enterprises.
Source: World Bank.

1. Introduction

Competitiveness pressures currently facing Romanian firms are inexorably tied to the opportunities and risks brough on by the green transition. Market shifts to greener practices and products will likely create new opportunities for the Romanian private sector, such as new markets for net zero products and services, integration into sustainable global value chains (GVCs), and productivity gains from innovation and the adoption of new (green) technologies. At the same time, these shifts create transition costs for Romanian firms, both in the form of changing demand conditions for greener products and from increased compliance costs brought on by the green policies and regulations adopted to address climate change, such as the European Green Deal and the EU Carbon Border Adjustment Mechanism (CBAM). Moreover, the private sector in Romania may also face significant costs due to intensifying physical risks directly brought on by climate change events, such as floods, droughts, or extreme heat. Despite elevated climate risks, the country's readiness to adapt remains low, which could hinder economic growth and exacerbate inequality.

Governments are increasingly recognizing that maximizing the benefits and minimizing the risks of the green transition requires smart industrial policies. Industrial policies are understood broadly as government interventions aimed at structural improvement in the performance of the private sector (World Bank 2026). Targeted incentives might be needed for the private sector to invest and innovate in the absence of adequate price signals. In addition, strategies that are mission-driven (i.e. organized around a specific societal or policy goal, e.g. decarbonization) and rely on new technologies — such as those targeting climate change mitigation and adaptation — can benefit some firms and sectors while leaving others behind, at least in the short term. This further necessitates government action in ensuring the green transition is equitable and in steering and coordinating policy interventions. The main obstacles to private sector decarbonization and greening include three broad categories. First, market failures[2], including externalities that are not reflected in prices, information gaps and uncertainty, weak incentives for green innovation, difficulties accessing green finance, natural monopolies, and coordination failures. Second, market distortions[3] — such as energy prices skewed by government subsidies, inadequate regulations and standards, barriers to the spread of green technologies, and poorly designed firm support programs that can slow rather than accelerate the transition. Third, limited firm capabilities — including low awareness, information gaps, behavioral biases, and weak managerial capacity.[4]

[2] A market failure is a situation where the market, left to itself, produces an outcome that is inefficient or socially suboptimal — meaning resources are not allocated in the best possible way.

[3] A market distortion is when a policy, regulation, or other external intervention causes prices or incentives to deviate from what they would be in a free, competitive market — leading to inefficient outcomes. Unlike a market failure, which arises from the market's own limitations, a market distortion is typically introduced from outside — often unintentionally or as a side effect of well-meaning policies. For example, a government subsidy on fossil fuels artificially lowers the price of energy, making it cheaper than it should be. This discourages firms from investing in energy efficiency or switching to cleaner alternatives, because the price signal they receive does not reflect the true cost of the energy they use.

[4] World Bank. Finance, Competitiveness, and Innovation. "Businesses and Climate Change." 2023.

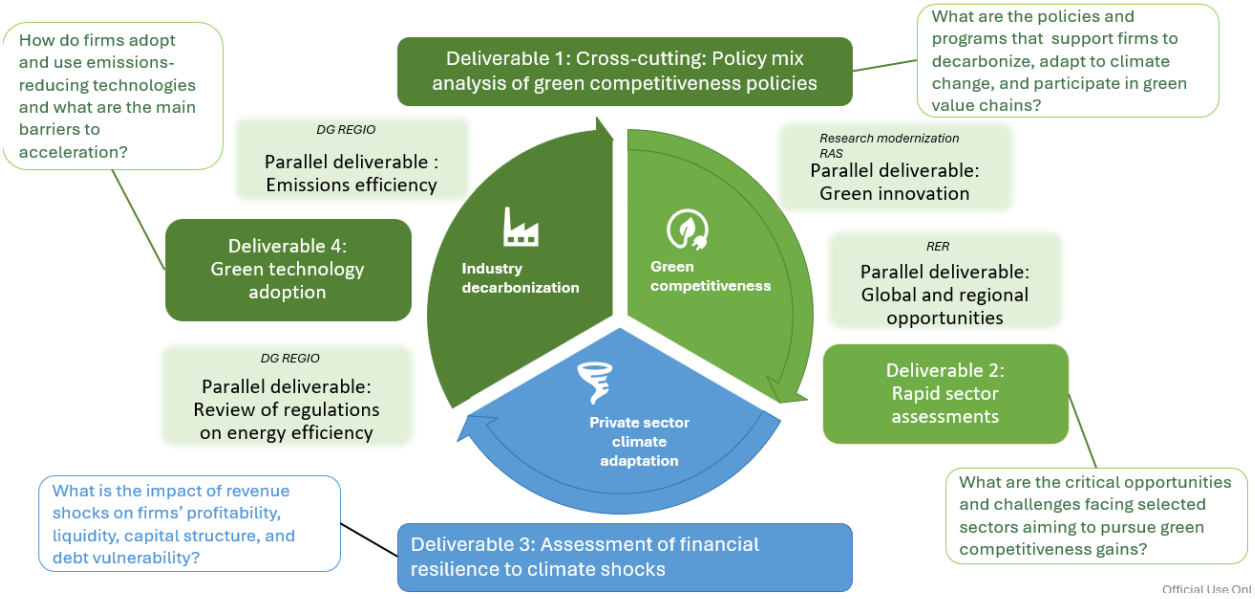
The recent World Bank flagship on industrial policy distills several key lessons for green industrial policy that are relevant for Romania (World Bank, 2026). The analysis highlights green industrial policy efforts that are particularly aimed at reducing the costs that traditional tradable sectors face in complying with emissions regulations. The report finds that emissions regulations, including emissions trading schemes, may require adaptation to avoid damaging the competitiveness of domestic industries. The analysis also shows that subsidies for adopting or inventing low-pollution technologies can reduce operating costs but may not promote energy conservation. The complexity of these inter-connected forces highlights the importance of green industrial policies in balancing the goals of emissions regulation with the need to address the broader structural barriers to competitiveness, such as skills, innovation, governance, and infrastructure.

The GRIN RAS provides inputs the Government of Romania in designing smart industrial policies with several robust analyses that can inform this shift to a green growth model that supports competitiveness while reducing emissions and improving resilience. The project informs both the competitiveness objectives of traditional industrial policy and the mission-oriented objectives of decarbonization and adaptation strategies that are critical for effective support of the private sector green transition.

2. How the findings of this report can support the green transition of Romanian firms

The deliverables of the GRIN RAS are organized around the three pillars of the green industrial transition—competitiveness, decarbonization, and adaptation—and constitute deep dives into specific key aspects of the policy landscape to derive lessons for improved effectiveness. Building on an initial cross-cutting report providing an overarching assessment of the existing green policy mix, these pillar-specific analyses form the core deliverables of the project (Figure 1). The main activities of the project are further complemented by parallel analytical work conducted under concurrent World Bank engagements.

Figure 1 The GRIN RAS is structured along the three pillars of decarbonization, competitiveness, and adaptation



Source: World Bank elaboration.

The core deliverables of the project are briefly described below, including an overview of related analytical work conducted under separate but concurrent World Bank engagements that informed the GRIN analyses: i) "Promoting the Energy Efficiency Transition of EU Firms" conducted with the European Commission's Directorate-General for Regional and Urban Policy (DG REGIO), where Romania was selected as a pilot country, ii) "*Research Modernization in Romania: Improving the Quality and Relevance of the Research* Sector", iii) World Bank's Regular Economic Review 10.

Cross-cutting:

- *"Private Sector Decarbonization, Competitiveness, and Adaptation to Climate Change in Romania: Policy Effectiveness Review of the Programs Supporting the Private Sector's Green Transformation."* This analysis provides an overall assessment of the effectiveness of the existing green policy mix and identifies gaps in its ability to support the green industrial transition (World Bank 2025).

Industry decarbonization pillar:

- *"Source of Emissions and Efficiency Opportunities for Romania"* (under DG REGIO project) presents the results of a decomposition analysis of GHG emissions at sector level, identifying firm segments with the highest emissions reduction potential and sector-specific emissions drivers (World Bank, forthcoming-d), benefiting from data from National Institute of Statistics used for the first time to conduct this type of analysis;
- *"Closing Romania's Technology Gap for a Greener, More Productive Economy."* This analysis is a deep dive into technology adoption at the firm level, including green technologies and management practices, drawing on technology adoption survey of a representative sample of 1,500 firms in Romania that offers granular findings on the gaps and barriers firms face in adopting green technologies (World Bank, forthcoming-c).
- "*Regulatory Landscape – insights from Expert Interviews in Poland and Romania on Barriers to Energy Efficiency Transition*" (under DG REGIO project) presents the results of a survey with experts within the identified sectors and a review of broader energy efficiency regulations to identify regulatory obstacles and good practices that can inform energy efficiency programs (World Bank, forthcoming-e).

Green competitiveness pillar:

- "*Batteries, Wind, and Plastics: Entry Points for Competitiveness in a Greener Economy."* This analysis provides a sample of three rapid sector assessments - the selection of which was partially informed by results of the decomposition analysis conducted under the DG REGIO project - illustrating emerging opportunities and defining and prioritizing policy actions and reforms that can drive Romania's green competitiveness agenda and accelerate the green transition of Romanian firms (World Bank, forthcoming-a).
- "*Policy Effectiveness Review of Science, Technology, and Innovation Policies in Romania : Analysis of the Policy Mix and Functionality of Support Instruments*" (World Bank 2024a) presents an assessment of the existing mix of innovation instruments in Romania, "*Note with the Assessment of Industry-Academia Linkages, Good-Practice Example(s) of Estimation of Resources, and Recommendations on Key Features of a Potential Program to Support Collaborative Research*" (World Bank, forthcoming-f) is a review of industry-research collaboration, "*Report on Improving Research Performance of Public Research Institutes in Romania: Assessment, Transformation, and Institutional Recommendations*" (World Bank,

forthcoming-g) presents an analysis of the capacity of public research organizations (all under Research Modernization RAS);

- "*EU Regular Economic Report 10: Clean Tech Value Chains, Part 2 – Using Trade Data to Guide a Complex Policy Space*" (under Regular Economic Review 10 project). This report analyzes opportunities for Poland, Romania, Bulgaria, and Croatia to participate in emerging EU clean-tech value chains, using trade and competitiveness data to identify potential areas for upgrading, growth, and job creation and to inform policy decisions related to clean-tech manufacturing (World Bank 2024b).

Private sector climate adaptation pillar:

- *"Assessment of Firms' Financial Resilience Against Climate Shocks in Romania*." This analysis provides critical estimates on the impacts of climate change on firms' financial vulnerability and corresponding funding demand to improve short-term liquidity and estimates the upfront costs of different fiscal and financial support packages.

The GRIN deliverables do not constitute a comprehensive green industrial strategy or industrial policy framework but reflect inputs that are directly relevant to the key challenges and opportunities for Romanian firms in the green transition. The findings and recommendations need to be complemented with further analyses, which can support the Government of Romania in selecting and defining specific policy packages necessary and sufficient to achieve the objectives of the Green Industrial Plan. The design and implementation of the Green Industrial Plan should be informed by rigorous consultations with relevant stakeholders (see Section 7 on public-private dialogue) and underpinned by sound government coordination. A recent example of an industrial policy framework is described for reference in Box 1 and could be used as a further input in the development of the Green Industrial Plan.

Box 1 Industrial policy framework

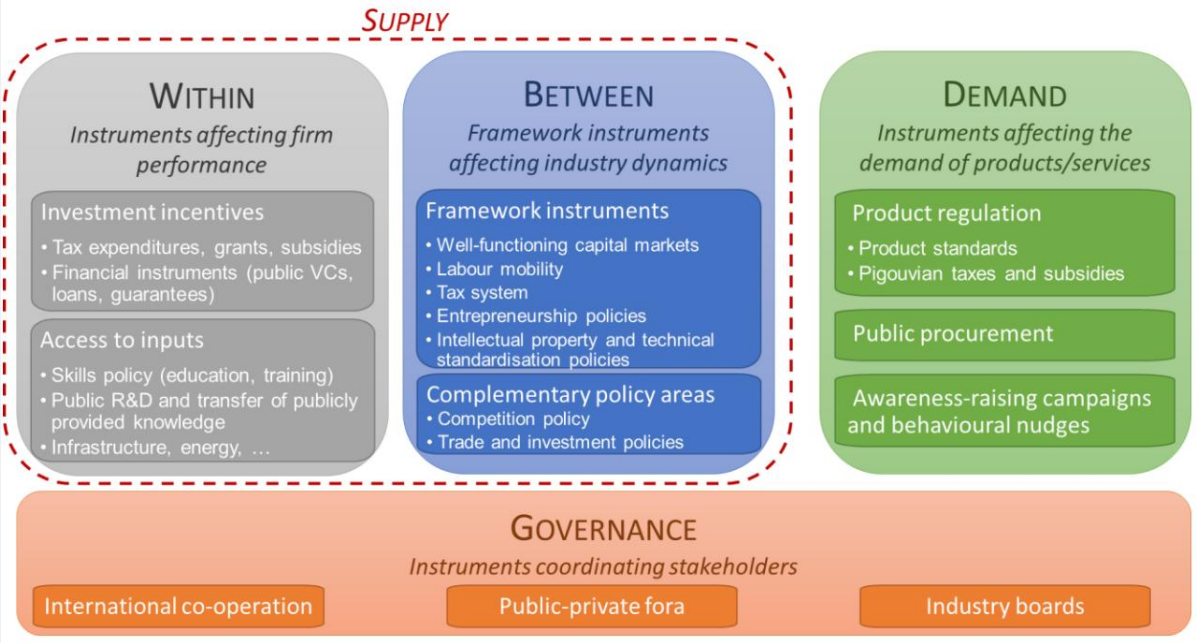
The following is a comprehensive framework for industrial policy support. The framework defines industrial policy as "interventions intended to improve structurally the performance of the domestic business sector". The framework is organized around the following principles: complementarity among policy instruments is critical and justifies the use of industrial strategies; targeted instruments can usefully complement horizontal policies, with the appropriate guardrails to avoid well-studies pitfalls;

The design of new industrial strategies increasingly focuses on achieving a given policy objective, such as a specific technology or mission, such as decarbonization, beyond traditional sectoral or place-based orientations. It is this defined objective of the industrial strategy that guides the selection of instruments; demand side instruments can contribute to transformational change and are increasingly common in mission-driven industrial strategies; and government need to put a strong emphasis on evaluation and regular re-assessment of targeted industrial policies.

The policy instruments chosen to be part of an industrial strategy can work through four main channels—between (supply); within (supply); demand; and governance—and have horizontal or vertical (targeted) scope. Demand-side policies increases the size and improve the quality of the markets that firm target, making them a natural incentive for firms to invest in greener production methods. Supply-side measure support firms in acquiring the capability needed, whether through sector wide instruments (that stimulate

a race to the top) or firm-specific instruments (that usually decrease risks in investing in green capabilities or increase the return on investment thereof). Governance oriented policies focus on reforms in the system or in the process that can render such green industrial policy sustainably enshrined in the state's mechanism.

In green industrial strategies, targeted instruments are particularly important to direct societal change and demand-oriented instruments can play a central role to limit environmental externalities and make demand more sustainable, indirectly incentivizing firms to go green, while supply-side instruments complement the effect by further incentivizing firms to develop and adopt green technologies.



Source: OECD 2022.

The GRIN sector assessments utilize this industrial policy framework and include vertical recommendations across for each of the assessed industries, as well as horizontal/transversal recommendations that support the development of the private sector in a sector-agnostic manner.

Source: OECD 2022.

This report brings together the key findings and recommendation of the deliverables under the GRIN RAS and parallel activities that aim to inform Romania's Green Industrial Plan. The report is structured along the three main interlinked and reinforcing pillars of competitiveness, decarbonization, and adaptation, and brings together concrete findings from all relevant analyses that inform each pillar. Several of the key findings of the report highlight constraints, such as technology adoption, managerial capabilities, skills, or innovation ecosystems, that are cross-cutting and relevant to all pillars. This summary report and all related analytical activities aims to support the Government of Romania by informing the design of policy reform and investment packages that can address the identified constraints and support the green transition of Romanian firms.

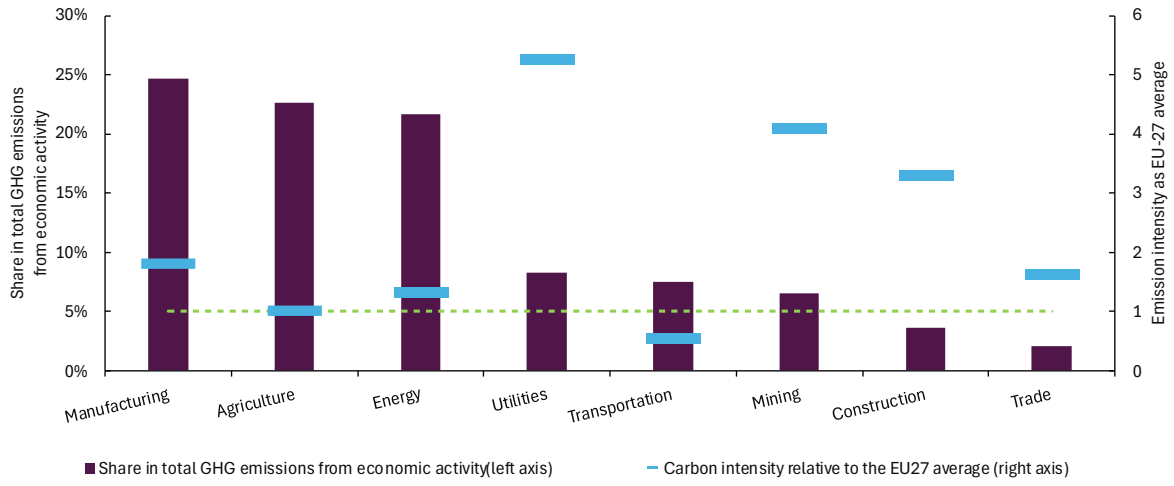
3. Industry decarbonization

Public sector support for industrial decarbonization is critical because industry plays a key role in the mitigation of GHG emissions and consequently, in Romania's efforts to contribute to global mitigation efforts, competitiveness, and energy security. Efforts to reduce GHG emissions contribute to the fulfilment of international commitments, but also support the competitiveness gains for firms, both through addressing transition risks, such as carbon policies, and through seizing opportunities in green value chains and green technologies. Such efforts can also support energy independence and resilience to negative external shocks, such as supply chain disruptions and fluctuating energy prices.

Even though Romania has effectively decoupled its overall economic growth from GHG emissions, the emissions intensity from economic activity in Romania is more than twice the EU27 average in 2022, reflecting both high emissions and low economic value-added. Consumption of energy resulting from economic activity in Romania accounts for 81 percent of total GHG emissions, with the remaining 19 percent originating from non-economic activities such as household heating and household transport. Romania's economic emission intensity stands at 0.54 kg GHG per EUR of value-added, significantly exceeding the EU27 average of 0.24 kg per EUR. Consequently, Romania ranks eighth in the EU for total GHG emissions, despite being only the seventeenth-largest economy in terms of value-added. This discrepancy suggests that elevated emission intensity in Central and Eastern European (CEE) countries, including Romania, stems not only from poor climate performance but also from lower value-added in production sectors.

In contrast to other CEE countries, Romania's high emission intensity, relative to the EU27 average, is driven primarily by industry and services, rather than by the energy sector. Manufacturing is Romania's top GHG emitter, with nearly double the average EU27's emissions per euro of value added. Romania's industry—manufacturing, mining, construction, and services sector—utilities and trade—together account for more than half of the country's economic activity GHG emissions, emitting significantly more GHG per euro of value added compared to the average firm in these sectors within the EU (Figure 2). The average manufacturing and trade company in Romania emits nearly twice as much GHG per euro of value added as its EU27 counterpart. Unlike in Bulgaria, Poland, and the Czech Republic, where high emission intensities result largely from coal-dependent energy sectors, Romania maintains comparatively balanced electricity generation, resulting in better energy sector emissions intensity. As manufacturing remains the largest single contributor to economic GHG emissions, it emerges clearly as the priority area for targeted decarbonization policies. More granular data and analysis on Romania's industrial sector and its evolution, trends in emissions over time, and other relevant background data in the GRIN Policy Mix deliverable (World Bank, 2025a).

Figure 2 In 2022, manufacturing in Romania had nearly double the emissions intensity of the EU27



Source: World Bank calculations, based on Eurostat.

Key finding 1: A small group of sectors presents outsized decarbonization challenges.[5]

In Romania, emissions are heavily concentrated in a small number of sectors and firms. A World Bank analysis used firm-level data from the National Institute of Statistics (INS) that covers around 50,000 Romanian firms from manufacturing, construction, and services sectors between 2010 and 2022 (World Bank, forthcoming-d). The analysis concentrated on enterprises within the regular economy and therefore excluded the following sectors: agriculture, forestry, mining, energy production, and petroleum-related activities.[6] It found that the ten most CO2-emitting sectors defined at the NACE-2 level account for 78 percent of private sector emissions[7], despite employing only 39 percent of its workforce (Figure 3). In comparison, wholesale and retail trade, comprising approximately 13,500 companies, dominate employment and revenue generation—contributing 39 percent of private sector revenues and employing 20 percent of the workforce—but are responsible for only 9 percent of emissions. The remaining eight CO2-emitting sectors include around 9,500 companies, primarily operating in road transport, cement production, roads and buildings construction, food production and chemicals. Consequently, most employment is concentrated in sectors with relatively minor emission impacts. Moreover, just ten companies producing cement, lime, and plaster employing approximately 3,000 workers emit more CO2 than the entire wholesale

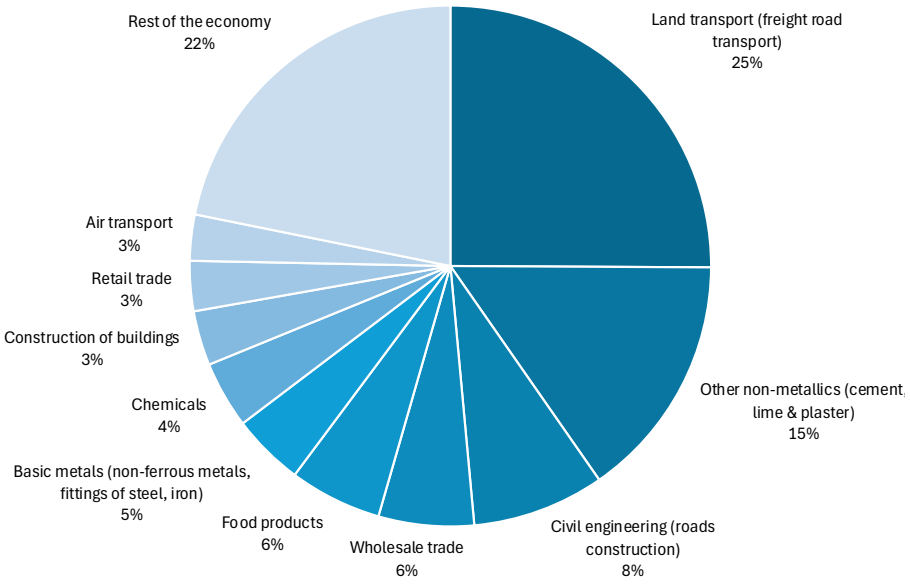
[5] This key finding is derived from World Bank (forthcoming-d). Please refer to Annex 1 a) for a detailed methodology.

[6] These sectors were excluded because they operate under fundamentally different conditions from the broader business economy. Agriculture and forestry emissions are largely biological in nature — driven by land use, livestock, and soil processes — rather than energy-related, making them difficult to analyze using standard firm-level energy efficiency or carbon intensity metrics. Mining, energy production, and petroleum-related activities represent the supply side of the energy system and are typically subject to distinct regulatory frameworks, ownership structures, and global market dynamics that fall outside the scope of a general firm-level decarbonization analysis.

[7] CO_2 emissions are estimated using emissions factors applied to firm-level energy quantities consumed, measured from a final consumption perspective. Estimates cover energy purchased and produced from other inputs across up to 50 energy carriers. Emissions from non-energy sources (e.g., industrial processes, land use change) and biogenic (e.g., biomass burning) are not included. Excluded from the calculations are energy-related sectors (e.g., electricity generation, oil and gas extraction, mining, refining), as well as Agriculture (A), Financial Services (K), Public Administration and Defense (O), and Social Work (88).

and retail trade sector, which employs more than half of a million people.

Figure 3 The top ten most polluting sectors in Romania in 2022 account for 78 percent of emissions



Source: World Bank calculations, based on data provided by the National Institute of Statistics (INS).
Notes: Sectors at 2-digit NACE level (in parentheses sector at 4-digit NACE level contributing the most to CO2 emissions).

Recommendations: *sector-specific decarbonization roadmaps (Rec. 3.1); horizontal instrument targeting (Rec. 3.3)*

Key finding 2: Bridging the emission intensity gap among firms could cut Romania's private sector CO2 emissions by almost half.[8]

A simulation shows that if firms with the emission intensity below the median (in their sector, for the firms with the same size) improved their emission intensity to match the median, private sector emissions could drop by 43 percent (World Bank, forthcoming-d). This benchmark of median in the sector for the same-sized firms reflects energy performance levels already achieved by similar firms in the country, therefore seems to be an attainable target. The simulation assumes that targeted firms' lower energy consumption while maintaining output, resulting in reduced energy use and decreased energy costs. This substantial CO2 reduction is entirely driven by firms operating below the median intensity threshold. Notably, the simulation focuses on improving emission intensity in inefficient businesses through firm-level actions that do not necessarily require large-scale investments or can be adopted without extensive technological knowledge. More than half of potential CO_2 emissions savings would be concentrated in just a few sectors, which helps focus policy efforts and guide prioritization. The simulation shows that six key sectors — basic chemicals

[8] This key finding is derived from World Bank (forthcoming-d). Please refer to Annex 1 for a detailed methodology.

and fertilizers, buildings and road construction, cement, lime and plaster, and freight road transport, and basic precious and non-ferrous metals — account for around 12 percent of firms and 9 percent of private sector employment but could collectively contribute 52.3 percent of potential private-sector CO_2 emissions savings. This translates to an intervention targeting around 5,500 firms.

Recommendations: *sector-specific decarbonization roadmaps (Rec. 3.1); horizontal instrument targeting (Rec. 3.3)*

Key finding 3: The highest emitting industries are often hard to abate and require different technological pathways.[9]

The highest-emitting industries are hard to abate and require sector-specific decarbonization pathways that go beyond incremental energy efficiency improvements. The six sectors with the highest simulated emissions savings, including cement, chemicals, fertilizers, construction-related activities, and freight road transport, are sectors where traditional energy efficiency technologies may be necessary but not sufficient to achieve significant emissions reductions. Depending on the sector, deeper decarbonization may require electrification, green hydrogen or other low-emission fuels, material and product substitution, circularity, and carbon capture, utilization and storage (CCUS). For example, CCUS may be critical for cement, where a large share of emissions comes from the calcination process rather than energy use; green hydrogen may be relevant for steel production; high-efficiency heat pumps can support lower-temperature industrial heat demand; and biomethane may be relevant for sectors with continued demand for gaseous fuels, such as glassmaking.

The current policy mix is not yet fully aligned with the sector-specific needs and maturity of these different decarbonization pathways. The Policy Mix report shows that Romania has substantial support for energy efficiency and fuel switching as a broad category, significant support for renewables, and visible support for hydrogen and biofuels. In fact, planned green hydrogen support may be relatively large compared with Romania's current hydrogen consumption, although this could be justified if future industrial demand grows as expected. By contrast, clearly dedicated funding for industrial electrification appears more limited. At the same time, there is no dedicated funding for CCUS or biomethane, despite their potential relevance for sectors with process emissions or gaseous fuels. Circular economy support also remains relatively small and only partly targeted at firms. Similarly, of the total €10 billion portfolio, construction receives 0 percent of targeted funding despite being one of the six key sectors. This uneven funding landscape reinforces the need for sector-specific decarbonization roadmaps that assess technical feasibility and cost-effectiveness and then align financing instruments and regulation (World Bank, 2025a).

Sector-specific roadmaps should build on existing work, but translate it into bankable Romanian implementation plans. Romania's Long-Term Strategy and updated NECP already provide high-level decarbonization trajectories, while the Hydrogen Strategy offers an initial view of future hydrogen demand. Romania-specific analytical work on CCUS and cement and lime also provides useful starting points, and EU transition pathways for sectors such as chemicals and

[9] This key finding is derived from World Bank (2025a). Please refer to Annex 1 b) for a detailed methodology.

construction, offer templates that can be adapted to the Romanian context. However, these inputs remain general, fragmented and are not yet converted into operational roadmaps for the highest-impact sectors. The proposed roadmaps should therefore consolidate existing evidence, validate assumptions with firms, banks, and infrastructure operators, and translate it into sequenced project pipelines with regulatory actions and financing instruments.

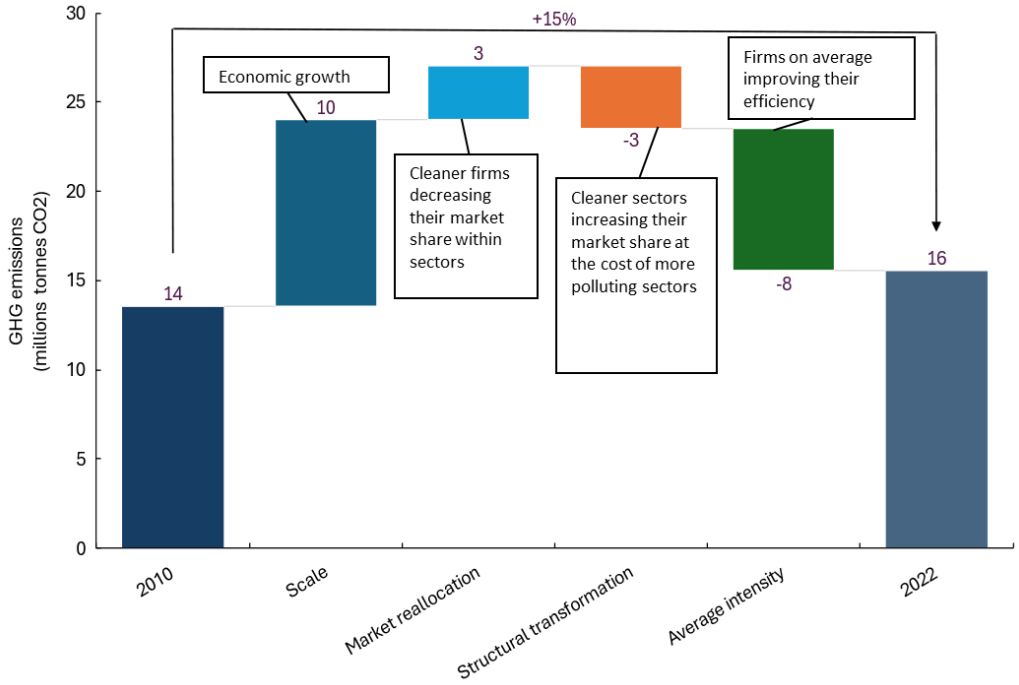
Recommendations: *sector-specific decarbonization roadmaps (Rec. 3.1); dedicated funding for CCUS and biomethane (Rec. 3.11)*

Key finding 4: Market forces in Romania do not favor energy-efficient businesses, despite significant efficiency gains.[10]

A critical finding from the firm-level analysis is that the market is actively working against decarbonization, channeling resources toward less efficient firms rather than more efficient ones (World Bank, forthcoming-d). In 2022, Romania's private sector emitted over 2 million more tons of CO2 than a decade earlier (Figure 4), primarily due to increased energy demand driven by economic growth (scale effect). Structural transformation helped mitigate emissions by 3 million tons, though its impact was less pronounced than in the 1990s. Meanwhile, firms' efforts to improve energy efficiency led to savings of 8 million tons of CO2 emissions (average intensity effect). However, these efficiency improvements have not translated into increased market shares for greener companies—on the contrary, market reallocation (the shifting of market shares between firms) has had a negative effect. More energy-intensive firms are gaining market share at the expense of more efficient ones. This is not a natural market outcome; it reflects regulatory and competitive market failures, including anti-competitive regulations, barriers to entry and exit, and energy cost shields that lower the price signal for all firms equally, allowing inefficient incumbents to maintain and expand their positions. Even where individual firms are improving their own intensity, aggregate emissions are not falling as fast as they should because productive reallocation is blocked.

[10] This key finding is derived from World Bank (forthcoming-d). Please refer to Annex 1 for a detailed methodology.

Figure 4 Economic growth and market reallocation have had a negative impact on CO2 emissions growth in Romania from2010-2022



Source: World Bank calculations, based on data provided by the National Institute of Statistics (INS).

Recommendations: *review market entry regulations (Rec. 3.4); assess energy price subsidies (Rec. 3.6)*

Key finding 5: Romania struggles to translate EU energy efficiency directives into clear, context-specific national regulations that are aligned with market needs and provide sufficient guidance for firms (regulatory quality)[11].

The transposition of EU directives to national laws is a core part of the EU's wider governance arrangement (World Bank, forthcoming-e). Ensuring EU laws are implemented in a way that is timely and in accordance with EU requirements as well as effective in national contexts can be challenging for many governments. The EU's 'implementation deficit' affects energy efficiency policies and measures as well as numerous other areas of legislation. Governments, for a range of reasons including lack of political will and/or insufficient capacity in ministries and implementing agencies, may struggle to develop effective governance mechanisms that go beyond formal publication of draft laws.

[11] This finding is derived from World Bank (forthcoming-e).

The transposition of EU Directives in Romania often lacks detailed, context-specific regulations and guidance to accompany national legislation. Experts[12] highlight that the legal framework for energy efficiency is largely a direct adoption of EU Directives, without adequate adaptation or detailed guidance for local implementation. For example, Romanian experts note a lack of domestic initiatives in designing energy efficiency policy measures tailored to national specificities, beyond EU requirements, which are themselves often vague. As a result, critical energy efficiency compliance information is usually provided by paid consultants, excluding firms that cannot afford them.

Experts also emphasized that communication between regulators and businesses is largely one-directional and consultation processes, when they occur, tend to be perfunctory. In Romania, energy experts rate public consultations as a critical barrier, citing infrequent engagement, primarily limited to public financing schemes. There is also a perception that the Ministry of Energy (MoE) has diminished capacity compared to when the Department for energy efficiency was under the Romanian Energy Regulatory Authority (ANRE), resulting in inadequate follow-up on industry legislative or regulatory proposals.

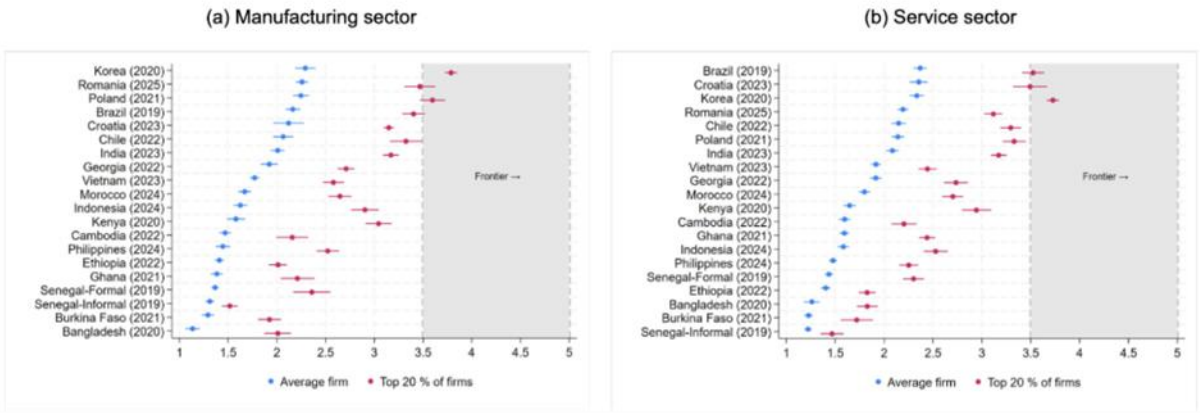
Recommendations: *strengthen environmental regulations (Rec. 3.5)*

Key finding 6: There are gaps in firm technology adoption, including green technologies [13].

A World Bank Firm-level Adoption of Technology (FAT) survey[14] found that Romanian firms perform well on average compared to other countries, although they are still far from being fully digitalized (World Bank, forthcoming-c). Aside from green technologies directly intended to reduce energy consumption, digital tools also drive energy efficiency by optimizing processes, reducing waste, and enabling smarter resource decisions. On aggregate, Romania's performance in 2025 is notable, ranking second in manufacturing digitalization and fourth in services across 19 benchmark countries (Figure 5)[15]. Yet this headline conceals significant gaps. The typical Romanian firm has adopted foundational digital tools but remains far from the frontier, scoring 3 out of 5 on the adoption index. Moreover, adoption is wide but not deep: the average firm scores only 2.2 out of 5 on intensive use, relying on basic technologies even in functions where more advanced tools are already available within the firm.

[12] The survey was conducted through guided semi-structured interviews with experts that were identified to have relevant knowledge of energy efficiency practices, regulatory frameworks, and market conditions in the sectors of focus.
[13] This key finding is derived from World Bank (forthcoming-c). Please refer to Annex 1 d) for a detailed methodology.
[14] The Firm-level Adoption of Technology (FAT) survey was conducted in 2025 on a nationally representative sample of over 1,500 Romania firms and benchmarked against comparator countries, such as Poland, Croatia, and Korea, to identify persistent gaps in technology adoption and key priorities to support the twin green and digital transitions.
[15] The FAT survey has been implemented across countries at different points in time, enabling international benchmarking while noting that comparisons reflect each country's survey year rather than a common reference period.

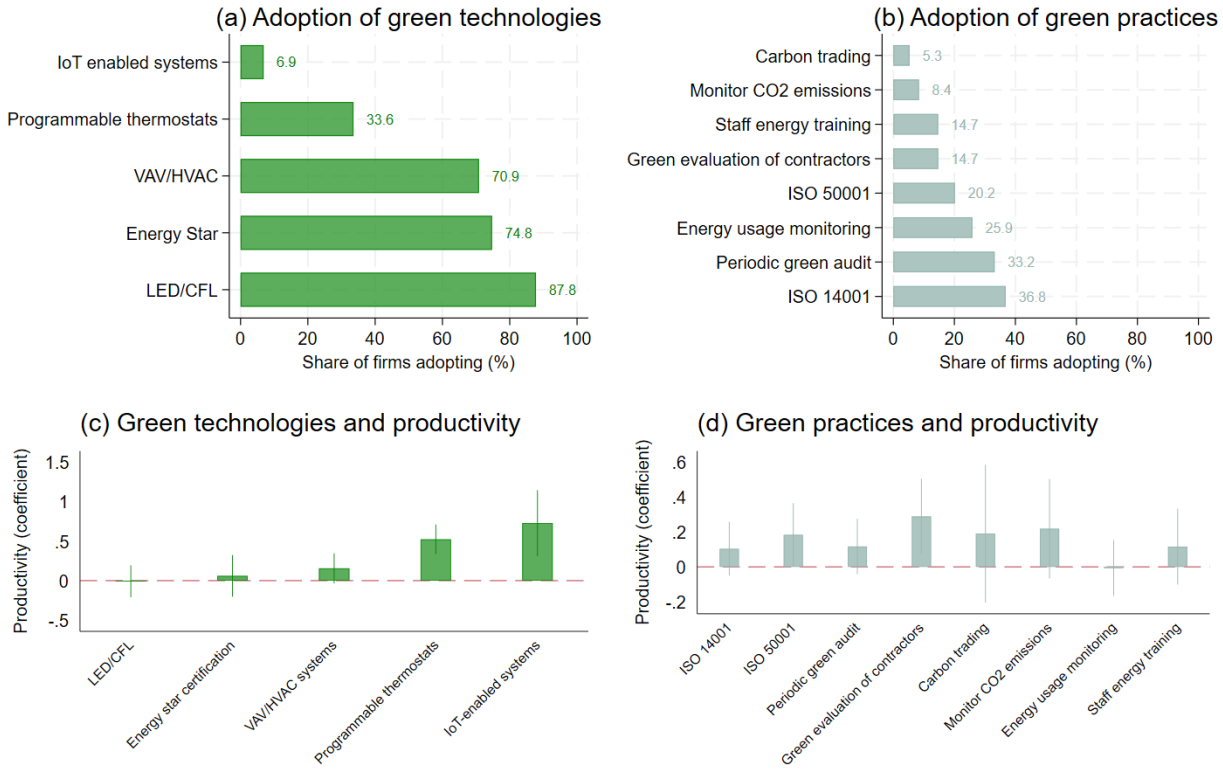
Figure 5 Romania's average firm is as digitized as the average Korean firm in 2020 and ranks fourth among 19 countries in services



Note: The figure plots for each country the average level of the technology index on intensive use, based on seven general business functions, and the top 20 percent of each country. Most basic technologies are indexed as 1, whereas technology frontier refers to firms with an index equal to 5. The circles correspond to the predicted levels of technological advancement as a function of the country of the survey considering sampling weights and controlling for firm size, sector, and age groups. Horizontal bars represent the 95 percent confidence intervals.
Source: World Bank analysis, based on data from all World Bank Firm-level Adoption of Technology Surveys available in 2025.

Green technology adoption in Romania is widespread but concentrated at the bottom of the sophistication ladder. The most common green technologies are low-cost, one-off investments that require little organizational change: 88 percent of firms have installed LED or compact fluorescent lighting, 75 percent use Energy Star-certified equipment, and 71 percent have basic heating, ventilation, and air conditioning systems (Figure 6, panel (a)). By contrast, adoption drops sharply for more advanced solutions with only 34 percent of firms using programmable thermostats and a mere 7 percent using IoT-enabled temperature control systems (Figure 6, panel (b)). This pattern matters for performance: while basic green technologies generate modest efficiency gains, more advanced tools are strongly associated with both energy efficiency and productivity (Figure 6, panels (c) and (d)). Similarly, green management practices associated with larger gains remain limited, with only 37 percent of firms holding ISO 14001 certification and 20 percent holding ISO 50001.

Figure 6 Romanian firms have predominantly adopted low-cost, basic green technologies and have limited uptake of technologies and practices that are strongly associated with productivity gains



Note: Top panels show the share of firms adopting green technologies (panel (a)) and management practices (panel (b)). In bottom panels, each bar shows how firms that use a given green technology (panel (c)) or practice (panel (d)) compare, on average, with firms that do not, in terms of labor productivity. Coefficients come from linear regressions of indicators of labor productivity (in log) on the adoption of specific green technologies and practices, accounting for sampling weights and controlling for firm size, sector, region, and city size, and total energy costs (in log) for energy efficiency. The thin vertical lines indicate uncertainty ranges (95 percent confidence levels): if they cross the zero line (red dashed line), one cannot be confident the difference is real; if they stay entirely above it, the difference is more reliable. N=1,516.
Source: World Bank analysis, based on data from the Romania Green Firm-level Adoption of Technology Survey conducted in 2025 (World Bank, forthcoming-c).

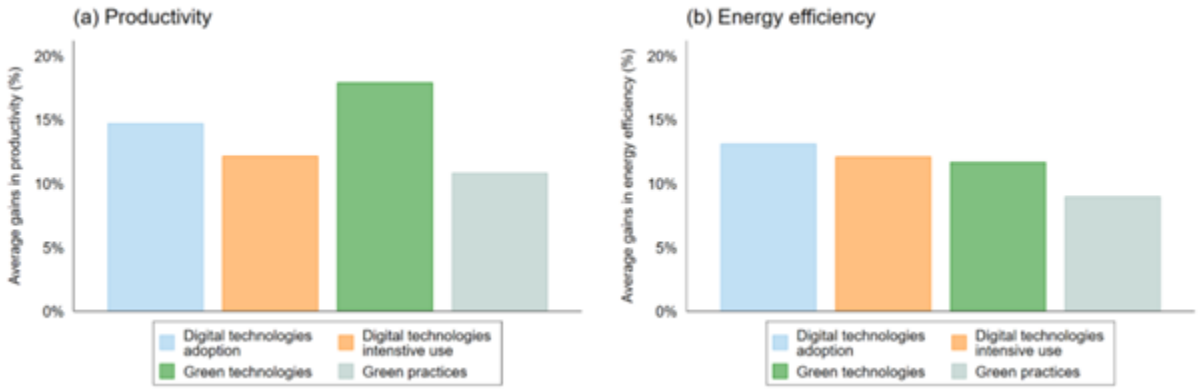
Firm-level factors explain technology outcomes more than sector or location, pointing to a large, untapped potential. The survey reveals that technology adoption varies across business functions, sectors, firm size, and regions, but the within-group dispersion is even more striking. This points to a large, untapped potential: many firms could benefit from digital technologies already used by peers of similar size operating in the same sector. Firm-level factors, such as management quality, workforce skills, and market integration, matter more than sector or location in explaining technology outcomes. The result is a polarized landscape, with a small group of digital leaders and a large majority relying on basic tools.

Recommendations: *digital maturity self-assessment tool (Rec. 3.12); consolidated information platform (Rec. 3.13); proactive outreach campaigns (Rec. 3.14)*

Key finding 7: Closing the technology adoption gap can yield substantial gains in productivity, energy efficiency, and job quality.[16]

Simulations based on the FAT survey show that if below-median firms caught up to the sector median level of digitalization, their productivity could increase by up to 15 percent and energy efficiency by up to 13 percent (World Bank, forthcoming-c) (Figure 7). Similar levels would be reached if focusing on the adoption of green technologies or practices, though potential gains in energy efficiency are highest from digitalization. Firms that adopt more advanced digital technologies also tend to perform better on green indicators, and both are largely shaped by common drivers and constraints, providing a strong rationale for policies that encourage digital upgrading as part of the green transition. The gap between digital adoption and use carries its own cost: firms using enterprise resource planning (ERP) systems in administration intensively see productivity gains three times higher than those that have the system in place but use it only partially. These findings extend to employment and wages, with more digitalized firms paying higher wages and creating more jobs.

Figure 7 Simulations show that lagging firms could, on average, improve productivity by up to 15 percent and energy efficiency by up to 13 percent by reaching the median level of adoption of digital technologies within the sector-size group



Note: The figure shows the estimated gains for firms with technology adoption below the median of their sector-size group if they were to catch up to the median, holding other factors constant. Gains are not additive across type of technologies. Panel (a) shows gains in labor productivity, and panel (b) shows gains in energy efficiency. Gains were calculated by multiplying the difference between each firm's actual level and the median by coefficients from linear regressions of labor productivity (log) or energy efficiency (log) on technology adoption indices. Regressions account for sampling weights and control for sector, region, and city size, with total energy costs (log) also controlled in panel (b). Estimated gains correspond to the average across all lagging firms. The sample is limited to firms whose level of adoption is below the median for their group: 734 (general technologies), 725 (intensive use of general technologies), 517 (green technologies), and 535 (green management practices).
Source: World Bank analysis based on data from the Romania Green Firm-level Adoption of Technology Survey conducted in 2025 (World Bank, forthcoming-c).

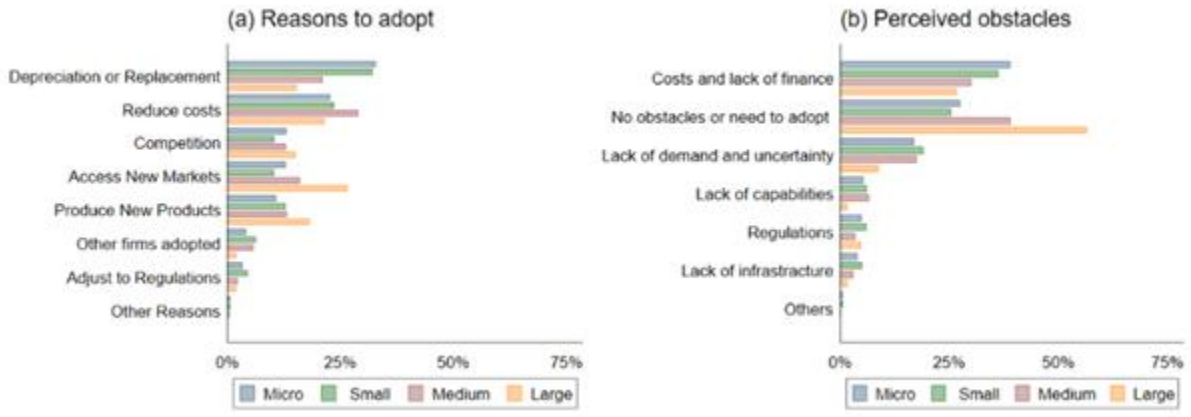
[16] This key finding is derived from World Bank (forthcoming-c). Please refer to Annex 1 d) for a detailed methodology.

Recommendations: *redirect grants toward technology adoption (Rec. 3.8); public co-investment programs (Rec. 3.9)*

Key finding 8: Access to finance is a key barrier to technology upgrading[17].

Many firms perceive financial constraints or low returns as a barrier to technology upgrading but better access to finance alone is not enough to drive adoption (World Bank, forthcoming-c). Financial constraints are the most reported barriers to technology adoption, cited by 37 percent of firms in the FAT survey, particularly MSMEs (Figure 8, panel (a)). The FAT survey shows that access to loans is associated with higher adoption of green technologies and management practices. Yet, Romania has the lowest level of financial intermediation in the EU, an MSME financing gap estimated at 26 percent of GDP, and 22.5 percent of firms have had a loan rejected — nearly three times the Europe and Central Asia average (IFC 2023). A survey of Romanian banks shows that bank lending for energy efficiency remains very limited and accounts for only 2.2 percent of total lending to non-financial firms, equivalent to €0.7 billion out of €32.6 billion in the reporting sample (8 banks). Energy efficiency lending is particularly weak in industry, where energy efficiency (EE) loans represent only 1.3 percent of total industrial lending, despite industry being responsible for roughly 35 percent of EU greenhouse gas emissions, while uptake is higher in sector, such as construction (5.8 percent) and professional and technical services (20.9 percent).

Figure 8 While financial constraints are the most cited barrier, many firms report no need to adopt and when they do, investment is driven by necessity rather than competitive ambition



Note: Firms were asked to mention the most important reason for or obstacle to technology adoption. Firm size categories are based on the current number of employees: micro firms employ 5–9 workers, small firms 10–49, medium firms 50–249, and large firms 250 or more. Answers are weighted by sampling weights. N=1,516.
Source: World Bank analysis, based on data from the Romania Green Firm-level Adoption of Technology Survey conducted in 2025 (World Bank, forthcoming-c).

[17] This key finding is derived from World Bank (forthcoming-c) and World Bank (Forthcoming-h). Please refer to Annex 1 d) for a detailed methodology underlying World Bank (forthcoming-c).

The bank survey identifies weak firm demand, rather than limited supply, as the main obstacle to expanding private financing for energy efficiency (World Bank, forthcoming-h). Two thirds of banks (67 percent) offer lower interest rates for energy efficiency loans than for conventional loans, indicating that EE projects are not seen as inherently riskier. Financial risk is ranked the least important obstacle, and approval rates for EE loans are broadly the same as for conventional loans (about 91 percent of banks report no difference). However, advisory services that could stimulate demand are offered by only 21 percent of banks, even though banks report that such services are effective when available. Meanwhile, public funding programs for technology adoption exist but remain largely unknown: only 19 percent of FAT survey firms report awareness of them. Uncertainty and slow rollout of these instruments may in itself reinforce firms' perceptions of financial constraints. Taken together, these findings suggest that expanding the supply of finance is necessary but not sufficient. This also implies that the proposed rebalancing from grants toward repayable and blended finance instruments will need to be accompanied by technical assistance, bank capacity building, and demand-generation measures, as discussed further under the recommendations.

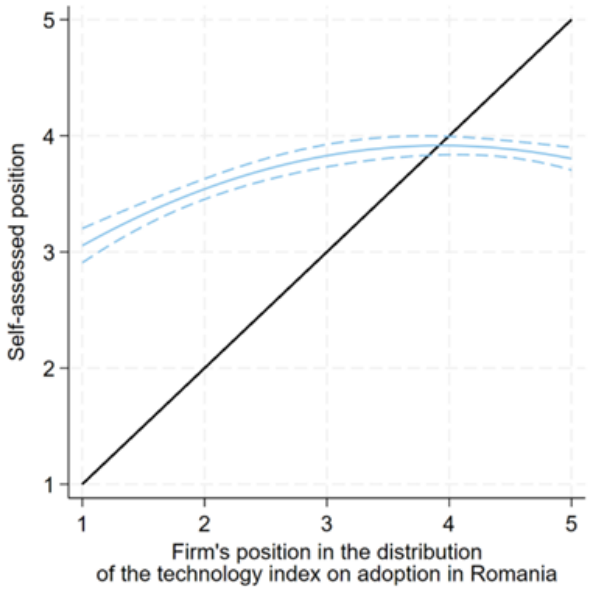
Recommendations: *redirect grants (Rec. 3.8); public co-investment programs (Rec. 3.9); pre-feasibility study for PCG schemes (Rec. 3.10); support specialized EE intermediaries (Rec. 3.18); targeted training on EE financing (Rec. 3.19)*

Key finding 9: Access to information and performance standards can incentivize firm upgrading but underlying tools remain fragmented[18]

Beyond finance, information and awareness gaps are a binding constraint on technology upgrading (World Bank, forthcoming-c). Despite most Romanian firms not using the most advanced technologies available, 58 percent overestimate their technological level relative to their actual position in the national distribution (Figure 9). Twenty-three percent report no obstacles and no perceived need to adopt new technologies (Figure 8, panel(b)). Taken together, these patterns point to information gaps as an initial binding constraint that must be addressed before financial instruments can be effective.

[18] This key finding is derived from World Bank (forthcoming-c) and World Bank (forthcoming-e). Please refer to Annex 1 d) for a detailed methodology.

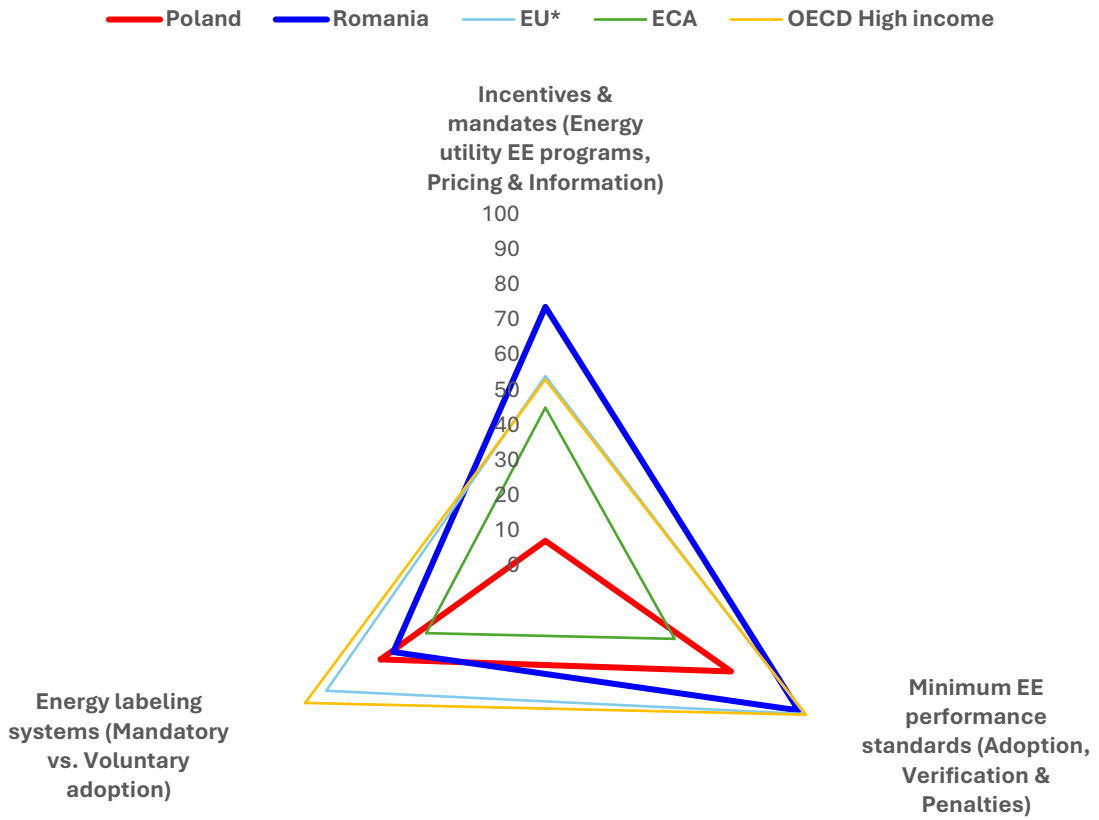
Figure 9 Firms less technology advanced tend to overestimate their position in the national distribution



Note: The figure compares firms' self-assessment of their technological advancement with their actual position in the national distribution of technology adoption. The 45-degree line represents perfect accuracy, where self-assessed and actual values coincide. The blue line shows the predicted relationship (quadratic) between self-assessment and actual position, with dashed lines indicating the 95 percent confidence interval. If the blue line is above the 45-degree line, firms tend to overestimate their sophistication; if below, they may underestimate it. Estimates account for sampling weights. Firms assess their technology level relative to others in the same sector in Romania. N=1,516.
Source: World Bank analysis, based on data from the Romania Green Firm-level Adoption of Technology Survey conducted in 2025 (World Bank, forthcoming-c).

For many firms, energy remains a relatively small cost share, which undermines the financial incentive to upgrade and increases the role of regulations and performance standards. As seen in Figure 8 (panel (a)), technology upgrading among Romanian firms remains largely reactive: 31 percent of firms cite equipment depreciation as their primary investment trigger, while competitive motivations — improving quality, entering new markets, reducing costs — remain weak (). Data from international benchmarking exercises (Figure 10) confirm that Romania made energy audits mandatory for large energy consumers, which can help firms overcome information barriers and reduce uncertainty about costs, savings, and payback periods. Romania also mandates energy management systems for large energy users, such as computer technologies. There is also a government or independent body that is responsible for approving third party auditors tasked with certifying energy efficiency standards and professional certification or accreditation programs for energy auditing, as well as for energy management, as well as adoption, verification, and penalties for minimum energy performance standards.

Figure 10 Romania exceeds EU levels of adoption of energy efficiency incentives and mandates, such as energy utility energy efficiency programs, pricing, and information



*Seven EU member states—Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia—are not represented in the RISE sample.

Note: The pillar score is the simple average of its indicators' scores. In turn, the indicators' scores are the simple average of the scores for sub-indicators. Each sub-indicator is comprised of a set of binary questions. The score for these questions is 100 if Yes and 0 if No. The average of those values produces the sub-indicators' scores.

Source: World Bank elaboration based on World Bank n.d.

Despite the existence of mandatory energy audits and emerging EMS support, the expert survey found that energy efficiency services markets in Romania remain fragmented, with weak links between information, investment, and implementation. Insufficient incentives to conduct energy audits, combined with weak enforcement of obligations to implement their recommendations, are persistent challenges. In the absence of mandates that companies act on audit findings, many audits rely on templates or standardized approaches rather than in-depth, site-specific analysis. This problem is compounded by a lack of effective verification systems, itself rooted in imperfect coordination among relevant agencies. In terms of energy management systems, Romania has not yet transposed the revised Energy Efficiency Directive; however, energy experts indicate that internal

EMS practices often exceed national legal requirements, which have not yet kept pace with the latest increased ambition on energy efficiency at EU level. This happens for local subsidiaries of EU companies, as well as for some exporters to EU countries where clients follow the latest EU requirements.

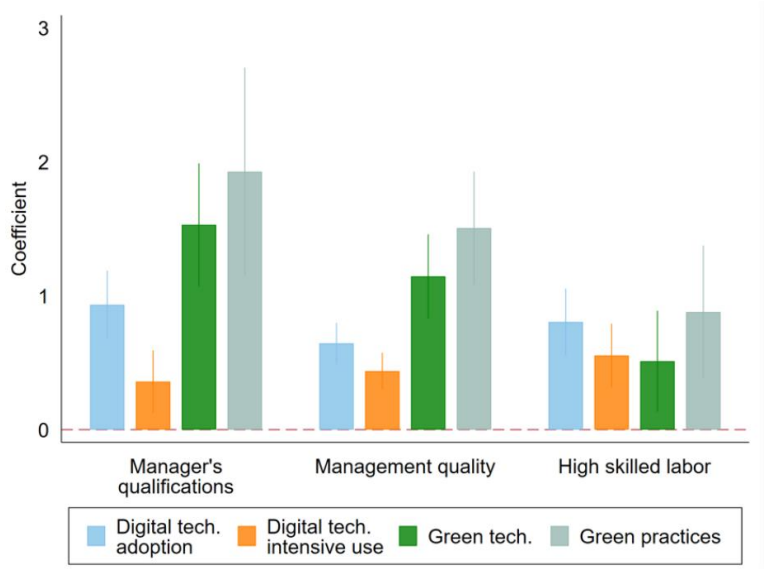
Recommendations: *environmental regulations (Rec. 3.5); energy price subsidies (Rec. 3.6); consolidated information platform (Rec. 3.13); proactive outreach campaigns (Rec. 3.14); independent energy auditors (Rec. 3.18); targeted training on EE benefits (Rec. 3.19);*

Key finding 10: Managerial and workforce skills are critical for technology adoption and integration[19].

Technology adoption does not deliver its full potential without the human capital to sustain it, and bridging this gap is particularly important for Romania's most advanced firms seeking to compete at the global frontier (World Bank, forthcoming-c). The findings of the FAT survey identify managerial and workforce capabilities as a binding constraint on adoption rates, but also on the intensive use of technologies once they are in place. Managers' qualifications and management quality are significant determinants of both adoption and intensive use, with effects particularly pronounced for green technologies and practices (Figure 11). Workers' capabilities show comparable effects, mattering especially for intensive use (World Bank, forthcoming-c), as employees are responsible for operating new systems after deployment. A particular concern arises at the top of the distribution: the FAT survey reveals a gap between Romania's most advanced firms and global digital leaders that widens among frontier firms and is larger in services than in manufacturing. Completing digitalization (moving from partial adoption to full integration) is particularly critical for Romania's most sophisticated firms. Yet the importance of human capital seems to be broadly underestimated by firms themselves: only 6 percent of firms cite capability gaps as a barrier to adoption. Investment consequently tends to favor hardware and tools over the skills needed to use them effectively (Avdeenko et al. 2026).

[19] This key finding is derived from World Bank (forthcoming-c). Please refer to Annex 1 d) for a detailed methodology.

Figure 11 Both managerial quality and workforce capabilities are significant determinants of technology adoption and intense use, with workforce skills mattering especially for intensive use



Note: The figure shows how technology adoption differs between firms with varying levels of workers' skills, managers' qualifications, and management practices. Workers' skills combine the share of employees with tertiary education and the share working as engineers, scientific professionals, or in research and development. Managers' qualifications combine education, sector experience, experience in large or multinational firms, and study abroad. Management practices combine non-family ownership, use of worker incentives, and use of key performance indicators. Coefficients come from linear regressions of technology adoption indicators on these factors, accounting for sampling weights and controlling for firm size, sector, region, and city size. The thin vertical lines indicate uncertainty ranges (95 percent confidence levels): if they cross the zero line (red dashed line), one cannot be confident the difference is real; if they stay entirely above it, the difference is more reliable. N=1,516.
Source: World Bank analysis, based on data from the Romania Green Firm-level Adoption of Technology Survey conducted in 2025 (World Bank, forthcoming-c).

Recommendations: *managerial capacity building (Rec. 3.15); post-implementation support (Rec. 3.16); workforce digital upskilling (Rec. 3.17)*

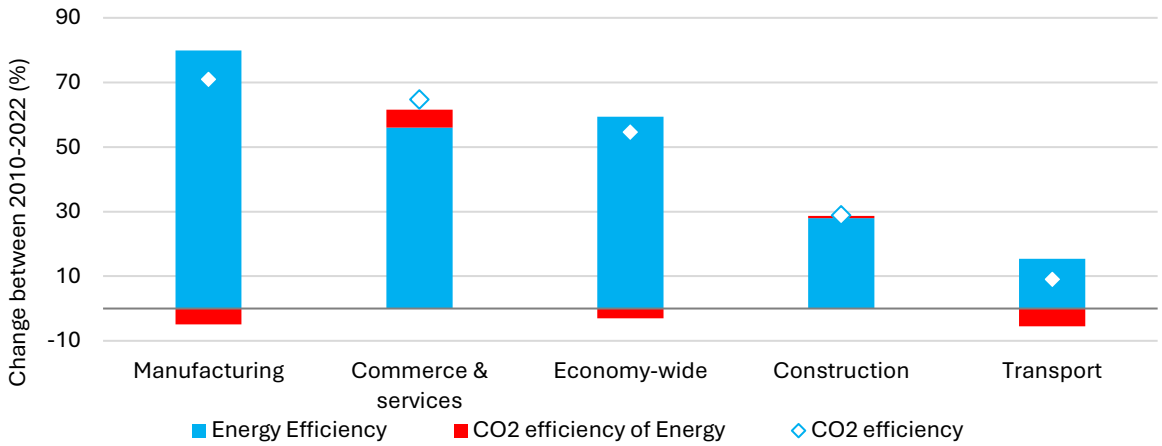
Key finding 11: Romanian firms are not gaining carbon efficiency by switching to green energy sources.[20]

Carbon efficiency depends on both how efficiently firms use energy and on how polluting their energy sources are and carbon efficiency in Romania does not seem to be coming from switching from brown to green energy sources (World Bank, forthcoming-d). Carbon efficiency—measured as output per unit of CO2—can be seen as the product of two components: energy efficiency (output per unit of energy) and the carbon intensity of energy (energy consumed per unit of CO2 emitted). Over the last decade, carbon efficiency gains across sectors were driven mainly by more efficient energy use, rather than by a shift toward cleaner energy sources. In fact, the carbon intensity of energy worsened economy-wide during this period, largely due to trends in

[20] This key finding is derived from World Bank (forthcoming-d). Please refer to Annex 1 for a detailed methodology.

manufacturing and transport (Figure 12). This may reflect the high costs firms face when shifting to cleaner energy, leading to underinvestment in machinery and equipment that relies on electricity or renewables rather than fossil fuels. The transition to a greener economy requires radical changes in the utilization of energy rather than marginal improvements that reinforce the dependency on currently high-polluting energy carriers. Improving carbon efficiency while maintaining the same energy mix yields diminishing returns, underscoring that fuel switching toward renewable sources is essential for further gains in carbon efficiency.

Figure 12 Romanian firms are improving their energy efficiency but not switching towards greener energy sources



Source: World Bank, based on data provided by the National Institute of Statistics (INS).

Source dependency appears to be high across Romanian firms and interfuel substitution might be costly in the short term. Economy-wide, most firms combine between two and four energy carriers, irrespective of the sectors they operate in. Two-tenths of companies (21 percent) depend exclusively on two energy carriers (especially in transportation), one-third (31 percent) on three, and one-quarter (26 percent) on four different sources. Including the 7 percent of plants that rely on a unique source, nearly nine of 10 companies require up to four different energy carriers, which suggests that the space to switch between fuels could be limited. Interfuel substitution within the firm may entail large capital adjustment costs. Switching across energy sources may be difficult and hard to achieve in the short term due to capital adjustments.

Recommendations: *expand self-consumption instruments (Rec. 3.2); regulatory assessment of solar photovoltaic (PV) barriers (Rec. 3.7)*

Key finding 12: Despite a relatively green energy mix, Romania is a laggard in the deployment of solar energy, especially for industrial self-consumption, which is a promising avenue for energy efficiency.[21]

Romania's solar potential is among the strongest in Central and Eastern Europe, yet deployment remains well below that of peers with comparable or less favorable conditions (World Bank 2025a). As of 2024, solar PV accounts for only 6.5 percent of total electricity generation, well below Hungary (approximately 24 percent), Bulgaria (14.3 percent), Poland (14 percent), and Greece (20 percent). The slow rise in capacity suggests that policy, regulatory, and market barriers continue to hinder large-scale deployment, despite strong cost incentives.

Currently, one of the most promising areas for solar PV growth in Romania is commercial and industrial self-consumption. Across the EU, self-consumption has become a key driver of solar deployment, particularly in the commercial sector. In 2023, 35 percent of new PV installations in EU were in commercial and industrial applications (SolarPower Europe 2024), a trend that Romania could leverage to accelerate solar adoption outside of large-scale utility projects.

The FAT survey found that energy insecurity may motivate on-site renewable production, but adoption rates remain low (World Bank, forthcoming-c). The results show that 44 percent of Romanian firms experienced power outages in 2024, and 28 percent own or share a generator, but only 9 percent currently produce their own renewable electricity on-site. Among those that do, renewable energy accounts for approximately 38 percent of their total energy consumption. Adoption is strongly size-dependent: the share of firms producing renewable energy rises from below 10 percent among micro-firms to over 30 percent among large firms. Geography also plays a role, with higher adoption rates in Macroregion 1 (North-West and Center) and Bucharest-Ilfov, while Macroregion 4 (South-West and West) lags significantly.

While southern Romania has high solar irradiation potential, limited incentives exist for firms to exploit photovoltaic investments. Unlike other high-impact green technologies, renewable energy adoption depends less on a firm's digital maturity and more on physical location and scale. Unlike most other green technologies, on-site renewable energy generation does not show a statistically significant association with firm-level productivity or energy efficiency, though benefits may take time to materialize and not be reflected in the cross-sectional nature of the survey data.

In addition, the portfolio mapping assessment found that the financing architecture of the renewables' financing instruments mix weakens market incentives for investment and misallocated resources (World Bank 2025a). Of the €2.35 billion renewables portfolio, 100 percent is delivered as grants, including for solar PV installations that are commercially viable across European markets without subsidy. This overreliance on grants for commercially viable projects reduces the public sector's ability to effectively support firms in investing in their own generation. In

[21] This key finding is derived from World Bank (2025a) and World Bank (forthcoming-c). Please refer to Annex 1 b) and d) for a detailed methodology.

addition, the ElectricUp program, the main self-consumption instrument, targets primarily hotels, restaurants, and cafés (HORECA) and small service businesses (budget: €215 million, contracted: €95 million by December 2024), leaving energy-intensive manufacturing, where the aggregate reduction potential is orders of magnitude larger, without a tailored equivalent.

Shifting from grants to financial instruments should be phased, targeted, and supported by capacity building across firms, banks, and implementing agencies. Grants should remain focused on activities where public additionality is highest, such as feasibility studies, early adoption incentives, and commercially immature technologies. For commercially viable investments with clearer cash-flow benefits, such as industrial energy efficiency, solar PV, and selected technology upgrading, Romania could pilot blended instruments combining guarantees, concessional loans, and limited grant components. Experience from Poland's NFOŚiGW and Germany's KfW/BAFA model shows that such a shift requires specialized institutions, advisory support, and sustained engagement with financial intermediaries. For Romania, the appropriate balance between grants, repayable instruments, and technical assistance should be treated as a priority topic for structured stakeholder consultation before instruments are scaled.

***Recommendations**: expand self-consumption instruments (Rec. 3.2); regulatory assessment of solar PV barriers (Rec. 3.7); redirect grants from commercially viable projects (Rec. 3.8)*

Table 2 Key short-term recommendations – Industry Decarbonization

Area	Short-term actions	Key Finding(s)
Strategy	**3.1 Design tailored, sector-specific decarbonization roadmaps** for each of the six key sectors, specifying the technological pathways appropriate to and the policy levers needed to activate them, including grants, concessional finance, technical assistance, and regulatory reform.	Key Finding (KF) 1, 3
	3.2 Expand the targeting of self-consumption instruments beyond HORECA to energy-intensive manufacturing and services, where the aggregate potential is orders of magnitude larger.	KF 11, 12
	3.3 Review the targeting logic of horizontal instruments (energy efficiency, fuel switching, new fuels) so that a defined, ring-fenced share of each instrument's budget reaches the six priority sectors.	KF 1, 3
Regulations	**3.4 Review competition and market entry regulations** to ensure that more efficient firms are not structurally disadvantaged relative to incumbent large emitters, restoring the market reallocation dynamic that should be driving aggregate emissions down.	KF 4
	3.5 Strengthen environmental regulations and the green aspects of the business regulatory framework to incentivize firms to invest in green technologies.	KF 5
	3.6 Assess energy price subsidies to understand the potential distortions and disincentives such policies can introduce.	KF 4

	3.7 Commission a comprehensive regulatory assessment of all barriers to solar PV deployment for self-consumption, covering permitting procedures, grid access, and legal uncertainty around net metering and self-consumption arrangements, and develop a time-bound action plan with assigned responsibilities for removing each barrier identified.	KF 12
Finance	**3.8 Redirect the use of grants from commercially viable projects**, such as technology acquisition or solar PV installation, toward needs assessments, transformation plans, and small adoption nudges to trigger adoption. Utilize blended finance, such as loans, guarantees, and partial grant components, for equipment financing channelled through the Investment Development Bank and commercial intermediaries.	KF 8, 12
	3.9 Establish public co-investment programs with a passive minority equity stake alongside private investors, through the planned innovation agency, to support more advanced firms in their transformative digital investments, where returns are long-term and uncertain and neither grants nor loans are adequate.	KF 7, 8
	3.10 Conduct a pre-feasibility study to explore the use and effectiveness of partial credit guarantee schemes and municipal co-financing schemes.	KF 8
	3.11 Introduce dedicated funding calls for decarbonization solutions that do not yet have financing, such as CCUS and biomethane production, that are informed by cost-effectiveness analysis, including demand, feasibility, and legal requirements.	KF 3
Access to information	**3.12 Promote a simple, harmonized independent digital maturity self-assessment tool**, building on the European Digital Innovation Hub (EDIH) Digital Maturity Assessment. It should be a mandatory entry point for any technology adoption support program, delivered through a centrally coordinated network of certified assessors.	KF 6, 9
	3.13 Consolidate the fragmented landscape of available technologies, programs, and financial instruments into a single, continuously updated platform, strengthening immentor.ro rather than building from scratch.	KF 9
	3.14 Utilize proactive outreach campaigns to actively target firms unlikely to seek technology adoption support on their own (MSMEs, firms in catching-up regions, and those reporting no perceived need to upgrade) leveraging peer effects through business associations and regional channels. This would include mandating EDIHs to actively reach firms, demonstrate technologies, and provide sustained on-the-ground support, starting with the most established hubs.	KF 9
Training	**3.15 Incorporate managerial capacity building** as a co-equal component of technology acquisition support, covering change management, digital transformation planning, and performance monitoring.	KF 10

	3.16 Provide sustained post-implementation support through IT helplines, troubleshooting guides, and follow-up advisory services to help firms move from initial adoption to intensive use.	KF 10
	3.17 Scale up workforce digital upskilling through training vouchers tied to accredited providers, anchored in Regional Development Agencies and the EDIH network.	KF 10
	3.18 Support specialized agencies with energy efficiency expertise or independent energy auditors to act as intermediaries between firms and banks and develop robust business cases.	KF 8
	3.19 Support targeted training programs for firms on the economic benefits of energy efficiency interventions and the available financing options.	KF 8, 9

Note: CCUS = carbon capture, utilization, and storage; HORECA = hotels, restaurants, and cafés; MSMEs = micro-, small and medium-sized enterprises; PV = photovoltaic.
Source: World Bank.

4. Green competitiveness

The green transition present significant competitiveness opportunities for Romania firms. Green competitiveness is defined as the ability of firms and sectors to increase productivity by leveraging environmental sustainability (including decarbonization) and climate resilience to maintain or enhance access to markets and participation in global value chains (GVCs).[22] It is critical that such green transition opportunities are supported by public sector policies and interventions to address the broader structural barriers to private sector growth, such as skills, governance, and infrastructure (IFC 2023). Technology upgrading can reduce exposure to transition risks, while market pivots to greener technologies, practices, and products can offer opportunities for growth and value addition, through productivity gains or access to new markets.

The Romanian economy is in a strong position to build on existing capabilities and capitalize on opportunities to participate in new green markets and products. Improved foreign direct investment (FDI) since EU accession, increased export complexity, and solid integration into GVCs have driven robust GDP growth of 3.8 percent per year for the past two decades. This puts Romania and its firms in a strong position to capitalize on opportunities in new green markets and products. In 2020, environmental (low carbon) goods and services amounted to 2.5 percent of Romanian GDP, exceeding the EU average (IMF 2023). These rising capabilities are reflected in an improved ranking (15th out of 230 countries and territories) on the Green Complexity Index, which tracks the capacity of countries to competitively export products that are green (i.e., offer environmental benefits) and technologically complex, and 22nd in green complexity potential, which suggests significant potential to build on its existing capabilities and unlock further opportunities for green and complex exports (IFC 2023). Its integration into GVCs is comparable to Germany's and exceeds the EU27 average. The relatively large domestic supplier base indicates significant potential for large spillovers on economic growth and job creation from participation in emerging green GVCs.

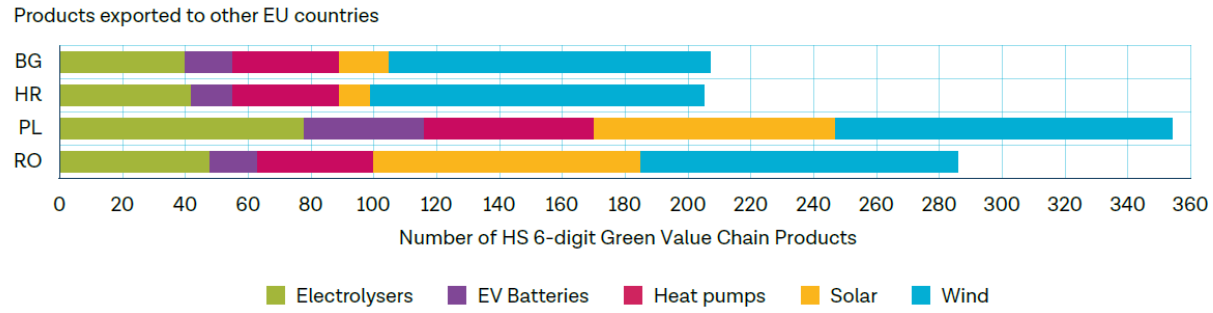
Key finding 1: Romania has significant untapped potential to increase exports in several clean tech value chains.[23]

A recent World Bank scenario assessment focused on four CEE Countries (Bulgaria, Croatia, Poland, and Romania) and five clean value chains, which produce durables required for the production or use of low-carbon energy (electrolysers, electric vehicle (EV) batteries, heat pumps, solar photovoltaic (PV), and wind). The four countries currently focus on subcomponents and products of medium complexity, indicating growing levels of sophistication and position in the mid-tier of these clean tech value chains (World Bank 2024b). A scenario analysis examined the product segments within the five clean tech value chains and considered what each country could onshore given the EU market's projected growth if Net-Zero Industry Act (NZIA) targets were to be achieved. By maintaining their current market share, Romania could potentially triple its technology-related exports in these clean tech value chains by 2030 if NZIA targets are met. If more ambitious NZIA

[22] A variation on the definition as adopted by the Romania Country Climate Diagnostic Report (World Bank 2023a).
[23] This key finding is derived from World Bank (2024b).

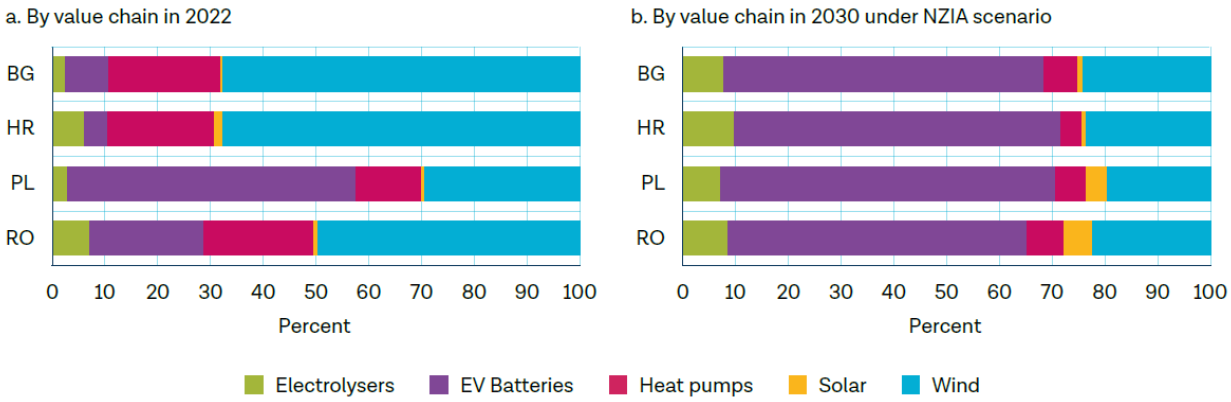
targets were achieved, such exports could quadruple in Romania. Romania has onshoring opportunities across all five value chains, most limited in battery production (Figure 13). Despite limited onshoring opportunities, and a small number of EU export partners, the export share of EV batteries to other EU countries is projected to have the highest increase under the 2030 NZIA scenario (Figure 14). This projection is driven by the expected growth in the segment due to the sevenfold growth target set by the NZIA and the sector's substantial value addition (30-40 percent of an EV's total value added). Substantial investment volumes will be needed, including from the private sector, to capitalize on this potential scale up in production.

Figure 13 Romania has the highest number of onshoring opportunities in the wind sector



Source: World Bank 2024b.

Figure 14 The export share of EV batteries from Romania to other EU countries is projected to have the highest increase under the 2030 NZIA scenario



Source: World Bank 2024b.

The GRIN RAS conducted three rapid sector assessments aiming to illustrate specific emerging opportunities that can potentially drive Romania's green competitiveness agenda (World Bank, forthcoming-a). The three sectors were chosen by the Government of Romania from a shortlist derived through a desk review and expert consultations. The shortlist included sectors combining green economy potential with high relevance to Romania's existing industrial base and decarbonization priorities. The shortlisted sectors were scored against three criteria: desirability (economic, environmental, and social benefits), feasibility (technical, financial, and political viability, as well as demonstrated global demand and local supply capacity), and additionality (the

degree to which the analysis would generate compelling new insights or catalytic impact beyond existing assessments). For more information on the selection process and assessment methodology, please refer to Annex 1. The assessment identified promising market opportunity within each analyzed sector, but the sectors are intended as examples rather than an endorsement of specific value chains for public sector support (World Bank, forthcoming-a). The following three findings (2-4) are therefore vertical in nature, while findings 5-8 are transversal. The analytical approach is replicable and should be applied to a broader range of sectors in the economy to identify more market opportunities that can drive the green competitiveness agenda.

Recommendations: *export and FDI promotion (Rec. 4.4); supplier-development services (Rec. 4.16); guarantee-backed transition finance (Rec. 4.18); research and innovation (R&I) and smart specialization (Rec. 4.22); MSME access to finance (Rec. 4.23)*

Key finding 2: The stationary energy storage market presents a compelling near-term competitiveness opportunity for Romania[24]

The in-depth sector assessment of the large format rechargeable batteries sector[25] reveals very limited opportunities in manufacturing battery cells for electric vehicles (World Bank, forthcoming-a). The global market is growing rapidly but is heavily concentrated: the five largest producers control roughly 75 percent of global output, and the capital investment required to operate at competitive scale—typically €3 to 5 billion per facility—is well beyond what could be justified given Romania's position outside the established EV battery corridors in Hungary and Poland. Global overcapacity is already driving prices down sharply, making conditions even more difficult for potential new entrants. Domestic demand is projected to expand, reflecting rising electrification across transport and industry, but not at a scale that can anchor large-scale battery cell manufacturing. Regional competition is an additional challenge, given that demand growth primarily reinforces incumbent ecosystems. Therefore, given these structural disadvantages, the more productive question for government is not how to enter cell manufacturing, but how to support Romanian firms in capturing value in adjacent segments of the EV supply chain—particularly wiring harnesses and connectors—where existing capabilities in metalwork and electrical engineering are directly applicable.

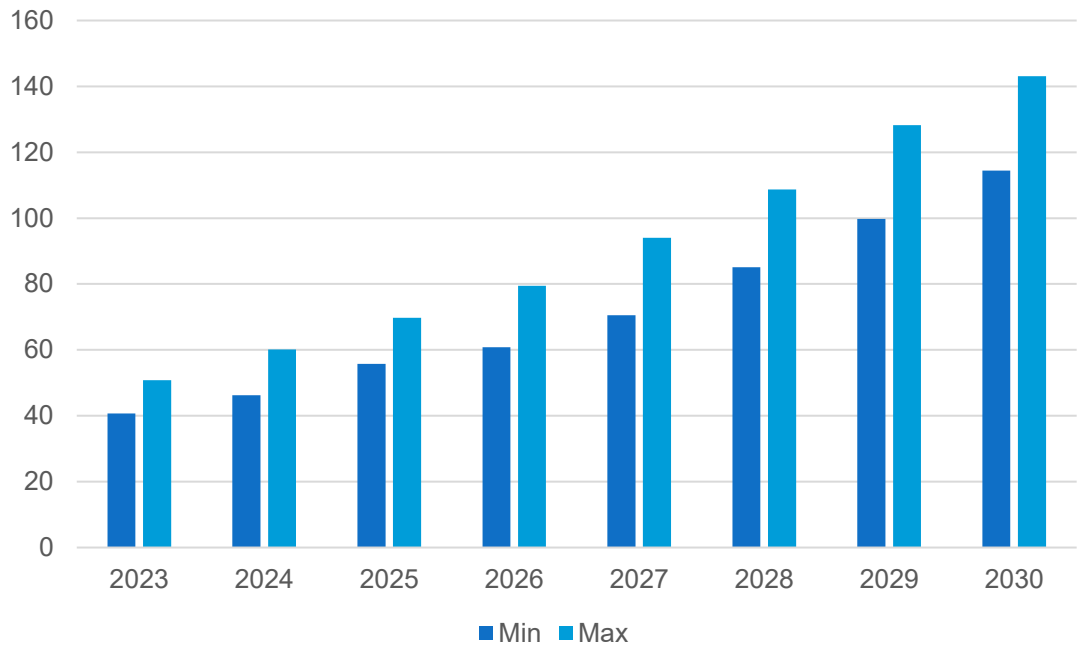
The analysis found that the stationary energy storage market, a related but distinct sector, presents a more feasible near-term opportunity for Romania. The stationary energy storage market focuses on rechargeable batteries that store energy to improve grid reliability by smoothing out generation from renewables, which is typically intermittent. Stationary battery energy storage systems rely on similar components, integration processes, and lifecycle management as EV batteries, but they are embedded in energy systems rather than global automotive supply chains.

[24] This key finding is derived from World Bank (forthcoming-a). Please refer to Annex 1 c) for a detailed methodology.

[25] Large format rechargeable batteries was one of the three sectors selected by the Romanian government based on a screening process combining green industrial potential with decarbonization priorities. The assessment is not an endorsement of the sector but rather a sample of the type of opportunity analysis that can be conducted on many similarly positioned sectors.

Storage is deployed as infrastructure, not consumer products, which shifts the balance from scale competition toward system integration, engineering, and policy design. The global storage market is large and growing. It was valued at roughly EUR 40–50 billion in 2023 and is projected to reach up to EUR 143 billion by 2030 (Figure 15). This market is younger, less consolidated, and shaped by national and regional grid conditions where geography and local expertise matter more, and the advantages of incumbency are smaller.

Figure 15 The global stationary energy storage market is projected to grow to EUR 143 billion by 2030



Source: International Energy Agency 2024; Statista 2024.

Unlike EV battery demand, which is determined by global automotive supply chains beyond Romania's influence, stationary storage demand can be shaped directly by national energy policy. Romania's pipeline of planned storage capacity is substantial: public funding commitments of €380 million are in place, and the government's target to expand intermittent renewable capacity from 7.8 GW to between 13 and 17 GW by 2030 creates a durable domestic demand anchor for storage. Installed operational capacity grew from 16.2 MW in mid-2023 to 82.4 MW by late 2024, with a 200 MW facility commissioned in late 2025, demonstrating that this market is moving quickly..

Romania already has a relevant industrial base connected to this opportunity, although it should be interpreted with caution. Key stationary storage value-chain segments—electrical components, transformers, battery management systems, cooling systems, power electronics, and system integration services—overlap with Romania's existing manufacturing and engineering capabilities. The mapped ecosystem comprises around 151 firms with capabilities relevant to the

EV battery value chain and a combined workforce of approximately 22,500 employees.[26] These firms—of which 67 percent are producers, 48 percent are service providers, and 52 percent are resellers (many firms fall play more than one role)—may be participating, or capable of participating, in activities across the large-format rechargeable battery value chain. As such, these figures should be treated as upper-bound ecosystem proxies, not as battery- or BESS-specific employment, because many of the firms concerned supply multiple sectors. The country's experienced engineering workforce is well-suited to the design, commissioning, and maintenance roles that stationary storage projects require. This opportunity is better understood as the upgrading and redirection of an existing supplier base rather than the creation of a fully new industry.[27]

Several challenges currently limit the extent to which Romanian firms can take full advantage of this opportunity. Commercial banks lack the experience to assess the revenue models of storage projects—which typically draw income from multiple sources simultaneously — leading to financing terms that many viable projects cannot meet. Grid connection bottlenecks and slow permitting processes add uncertainty and cost to project execution, raising the perceived risk of investment. A fragmented local ecosystem and continued dependence on imported technologies, despite the existing industrial base, present a further constraint to scaling up. There is also a shortage of workers with training in the specific technical disciplines the sector requires, including energy management systems and battery performance analytics. FDI attraction and capacity is lagging, with no coherent battery industry roadmap. Finally, the regional competition for battery and storage investment is intensifying, particularly from Hungary and Poland, which have moved quickly to establish comprehensive industrial ecosystems and clearer investor propositions.

More granular assessment of the competitiveness of Romanian firms in the stationary energy storage market, including export opportunities, integration with value chains, competition with imports, etc. can be found in the GRIN Sector Assessments deliverable (World Bank, forthcoming-a).

Recommendations: *grid-fee exemption for storage (Rec. 4.1); five-year storage procurement plan (Rec. 4.2); fast-track permitting for BESS (Rec. 4.3); export and FDI promotion (Rec. 4.4); financial sector readiness framework (Rec. 4.5); loan guarantees for BESS manufacturing (Rec. 4.6). The analytical underpinnings for the sector-level recommendations for the stationary energy storage market are described in greater detail in the sector assessment deliverable (World Bank, forthcoming-a).*

[26] Analysis of Romanian firms with capabilities relevant to the EV battery value chain identifies around 151 firms and approximately 22.500 employees, while also emphasizing that the more promising Romanian opportunities lie in battery pack components and especially BESS pack components, system integration, and maintenance.

[27] Evidence on Romania's adjacent electrical-manufacturing base shows exports of overlapping products such as electrical boards, transformers, and related control equipment rising from about €3,2 billion in 2013 to about €8,7 billion in 2023; comparative advantage is strong in electrical boards and weak in batteries themselves. Employment growth in the broader potential EV battery value chain is concentrated mainly in components rather than in batteries or packs.

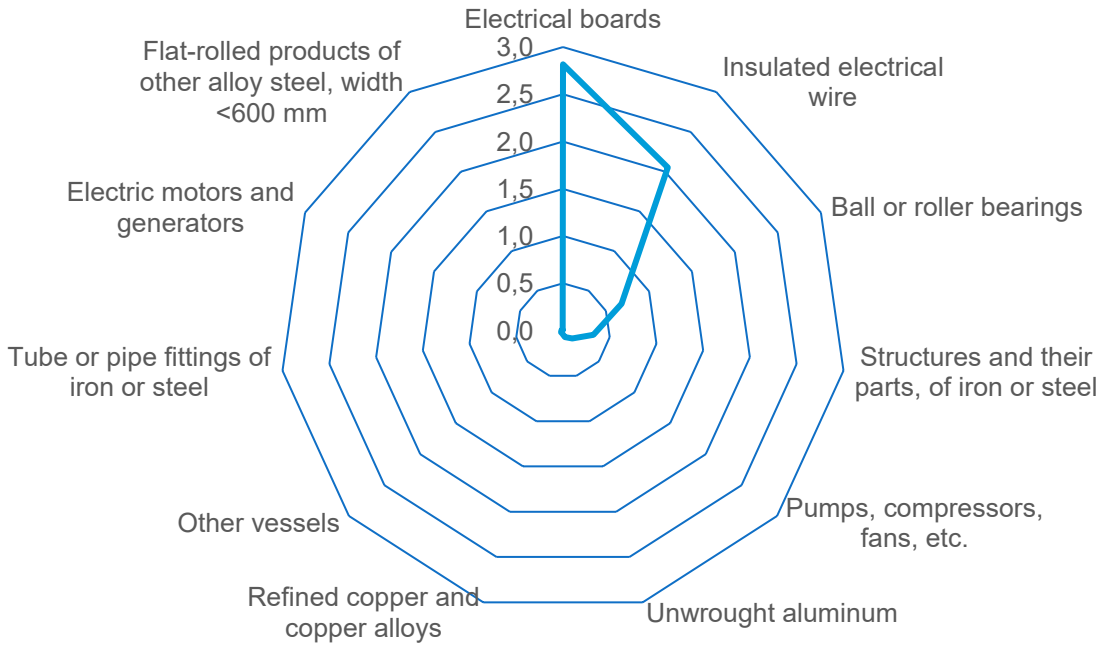
Key finding 3: There are promising opportunities for Romanian firms in components and services related to the wind energy sector[28]

The in-depth sector assessment of the wind energy value chain reveals that Romania's competitive prospects vary considerably across the wide range of activities within the value chain[29](World Bank, forthcoming-a). Manufacturing the largest structural components, such as blades exceeding 60 meters in length and towers weighing over 100 tons, requires proximity to ports and reinforced transport infrastructure that Romania does not yet have at the necessary scale (World Bank, forthcoming-a). It also means competing directly with established hubs in Poland and Turkey. Turkey alone hosts 13 wind component factories exporting 80 percent of their output. Pursuing these segments in the near term would mean entering from a position of significant structural disadvantage.

The more compelling opportunities lie in components and services to serve the electrical and civil infrastructure that connect turbines to the grid and keep them running. Romania already has demonstrated strengths in the relevant product categories: substations, transformers, switchgear, cables, and power electronics. The largest surpluses are in electrical boards (EUR 2.8 billion) and insulated electrical wire (EUR 2.05 billion), indicating that Romania is a major exporter of electronics also essential for wind turbines and grid integration (legacy in the auto sector). Significant surpluses in ball or roller bearings (EUR 683 million) and iron/steel structures (EUR 324 million) reflect domestic production of key mechanical parts that could be used in wind turbine assembly and infrastructure (Figure 16). For small, distributed installations, proximity, customization, and short lead times matter more than the scale economies that favor established Western European suppliers. The limiting factor is not manufacturing capacity but supplier readiness: many domestic firms lack the international certifications—ISO standards, health and safety accreditation—required by major turbine manufacturers to qualify for supply contracts beyond basic subcontracting. Closing this gap would allow Romania to capture a larger share of project value as its own deployment pipeline grows.

[28] This key finding is derived from World Bank (forthcoming-a). Please refer to Annex 1 c) for a detailed methodology.
[29] The wind energy sector was one of the three sectors selected by the Romanian government based on a screening process combining green industrial potential with decarbonization priorities. The assessment is not an endorsement of the sector but rather a sample of the type of opportunity analysis that can be conducted on many similarly positioned sectors.

Figure 16 Romania has large surpluses in electrical boards, insulated wire, bearings, and steel structures



Source: Harvard Growth Lab n.d.
Note: Total imports (2023): EUR 139 billion; total wind energy value chain imports (2023): EUR 12 billion.

Romania already has a significant industrial and service base connected to the wind-energy conversion-system value chain. The mapped ecosystem comprises 177 entities, of which 97 are classified as service providers, with activity spanning core components, sub-components, structural suppliers, electrical equipment, and lifecycle services. Across the mapped firm set, reported totals include approximately 23,256 employees, €3.7 billion in aggregate turnover, €2.9 billion in sold production, and €1.1 billion in fixed assets. These figures should be treated as upper-bound ecosystem proxies, not as wind-only activity, since firm-level business lines are not limited to wind. Romania also has a large and technically capable workforce, with strong engineering depth and established pathways for vocational upskilling and reskilling. Labor costs remain comparatively attractive: average hourly labor costs in Romania are among the lowest in the EU, strengthening cost competitiveness for component manufacturing.

Several challenges stand above the rest as constraints on Romania taking advantage of these opportunities. The predictability of project execution remains poor. Permitting involves multiple

agencies with overlapping mandates, grid connection requirements are subject to change, and the allocation of connection risk between developers and the system operator is not clearly defined. These uncertainties raise the cost of capital for domestic firms relative to established foreign incumbents who can absorb risk across larger portfolios. In addition, the predictability of demand remains insufficient for domestic manufacturers to justify investment in upgrading their capabilities and certification. Without a clear, multi-year signal of how much capacity will be procured and when, the business case for supplier upgrading is difficult to make. A bankability gap persists across the full utility-scale wind value chain, extending beyond project finance to manufacturers and service providers. The broader ecosystem has limited access to de-risking architecture, but the fragmented and incomplete risk-sharing mechanisms increase the price of capital and delay expansion decisions. Finally, a supplier upgrading and service-readiness gap leads to opportunistic rather than embedded value chain participation, further limiting local value capture.

Recommendations: *rolling contract-for-difference (CfD) auction calendar (Rec. 4.7); non-price auction criteria (Rec. 4.8); wind delivery unit (Rec. 4.9); supplier qualification program (Rec. 4.10); supplier-development services (Rec. 4.16); business support institutions (Rec. 4.21). The analytical underpinnings for the sector-level recommendations for the wind energy market are described in greater detail in the sector assessment deliverable (World Bank, forthcoming-a).*

Key finding 4: Sustainable high-volume recyclable packing presents a competitive opportunity for Romanian firms[30]

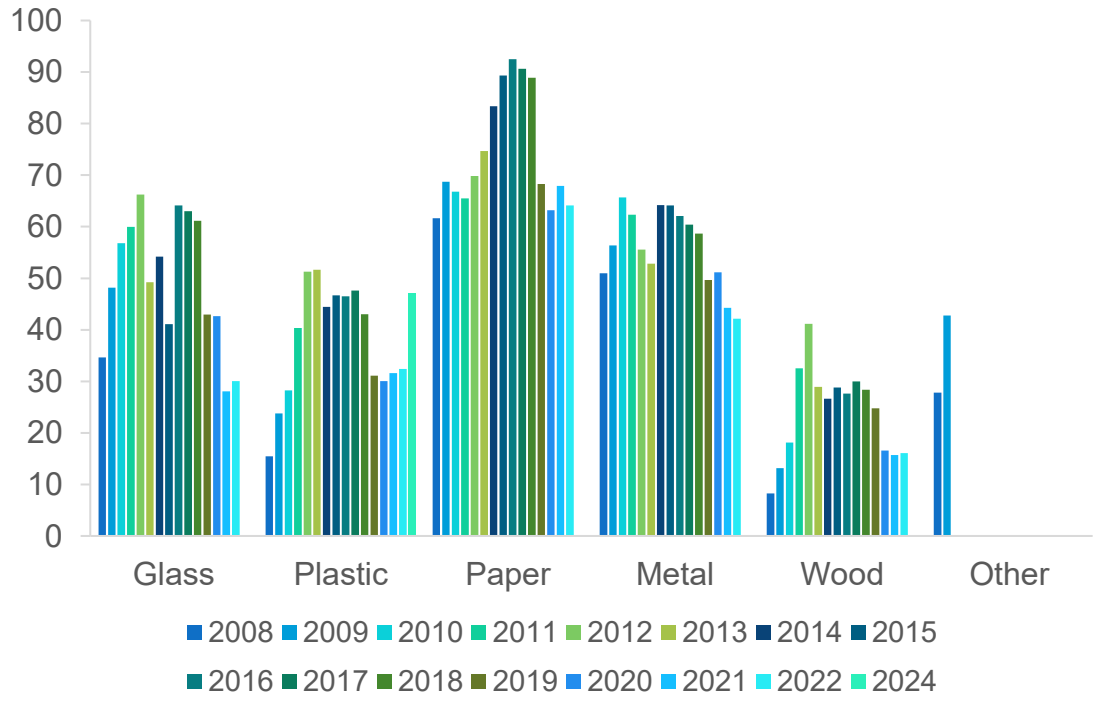
The in-depth sector assessment of the plastic packaging sector[31] reveals that Romania is presented with a distinctive opportunity—one driven primarily by regulatory change rather than by technology shifts or resource endowments (World Bank, forthcoming-a). A wave of EU legislation, most importantly the Packaging and Packaging Waste Regulation (PPWR), is creating mandatory demand for packaging that is recyclable, made with recycled content, and designed for reuse. Firms that can supply compliant formats at competitive prices stand to gain durable market positions both domestically and in the broader EU market. Romania's existing manufacturing base, its cost structure, and recently built recycling infrastructure together constitute a credible starting point.

Romania already has a substantial industrial base connected to plastic packaging, but the opportunity is concentrated in downstream conversion and circular upgrading rather than in upstream resin production. The plastics industry in Romania includes about 1,177 companies, and industry revenues increased from about €484 million in 2012 to about €773 million in 2022, with further growth projected by 2025.[32] Demand is concentrated in the food and beverage segment,

[30] This key finding is derived from World Bank (forthcoming-a). Please refer to Annex 1 c) for a detailed methodology.
[31] The plastic packaging sector was one of the three sectors selected by the Romanian government based on a screening process combining green industrial potential with decarbonization priorities. The assessment is not an endorsement of the sector but rather a sample of the type of opportunity analysis that can be conducted on many similarly positioned sectors.
[32] Romanian sector analysis identifies about 1.177 firms in the plastics industry, with revenues rising from about €484,36 million in 2012 to about €772,54 million in 2022 (World Bank, forthcoming-a).

which accounts for approximately 53 percent of plastic-packaging use, and the material mix is dominated by common packaging plastics, especially polyethylene and polypropylene.[33] The strongest current base sits in packaging conversion: 348 firms in packaging goods, 264 in plastic sheets/films/tubes, and 467 in other plastic products.[34] In addition, the recycling sector comprises more than 950 companies, around €2.06 billion in revenue, and more than 10,600 employees; the country also reports plastic-packaging recycling rates of about 32 percent in 2022 and 47 percent in 2024, with the increase partly due to the introduction of Romania's Deposit Return System (DRS) (Figure 17).[35] By contrast, the upstream resin-production base is small, with only 98 firms and around 3,730 employees, while raw-material trade remains strongly import-dependent.[36]

Figure 17 Plastic packaging recycling rates were 47 percent in 2024 partly supported by the introduction of Romania's DRS system



Source: Plastics Europe 2024; National Institute of Statistics 2026.

Not all segments of the plastic packaging value chain are equally accessible. Upstream resin and polymer production requires very large capital investments to achieve competitive scale, faces

[33] Romanian sector analysis reports that food and beverage accounts for around 53 of plastic-packaging demand (World Bank, forthcoming-a).
[34] According to Romanian sector analysis, packaging conversion includes 348 firms in packaging goods, 264 in plastic sheets/films/tubes, and 467 in other plastic products (World Bank, forthcoming-a).
[35] Sector analysis reveals that the recycling sector comprises more than 950 companies, around €2,06 billion in revenue, and more than 10.600 employees. Romania reports plastic-packaging recycling rates of about 32 percent in 2022 and 47 percent in 2024 (World Bank, forthcoming-a).
[36] Based on Romanian sector analysis, upstream resin production comprises 98 firms and around 3.730 employees (World Bank, forthcoming-a).

global oversupply, and is burdened by high European energy costs—conditions that make entry unlikely to be commercially viable in the near term. Similarly, integrated circular packaging services—specialized technical services for packaging design and certification—depend on the depth of specialist expertise that takes considerable time to build. The opportunity where Romania's competitive position is clearest is sustainable high-volume recyclable packaging: single-material designs for bottles, trays, and flexible films that are manufactured at scale and can meet the recycled-content requirements that EU regulations are beginning to mandate.

Romania's competitive footing in this segment rests on three foundations. The first is cost: manufacturing labor costs in 2024 stood at €12.50 per hour, less than 40 percent of the EU average, while productivity remains at approximately 80 percent of the EU norm. The second is the existing active base of firms producing the formats this segment covers, such as flexible plastic packaging and films. The broader packaging sector—though fragmented, with no single company holding more than 5 percent market share—already serves export-oriented food, beverage, and home-care supply chains that are subject to EU compliance requirements. Romania's total plastic product exports are projected to reach approximately USD 2,5 billion by 2028, indicating that the export orientation needed to access EU buyers at scale is already present. And the third foundation is the country's Deposit Return System, which achieved an 84 percent collection rate for beverage containers in its first full year of operation, generating a reliable, high-purity stream of recycled material that meets food-contact quality standards. Few countries in the region have built this feedstock infrastructure as quickly or effectively, and it is a genuine competitive asset for packaging producers who need traceable recycled input.

Several challenges currently limit the extent to which Romanian firms can translate this potential into market position. Non-compliant imports—often mislabeled products from outside the EU—are undercutting compliant domestic producers by 40 to 50 percent in some market segments. If firms that invest in compliant packaging designs cannot recover their costs because non-compliant alternatives circulate freely, the business case for investment collapses. In addition, Romania has no accredited domestic facilities for the testing and validation that packaging compliance requires—such as food-contact safety testing and recyclability trials—forcing firms to use foreign laboratories at significant cost and delay. Financing for the equipment the transition requires remains inaccessible to many firms: collateral requirements are high while converters tend to be asset-light, and public instruments are fragmented. A skills gap further compounds these constraints: the education system does not reliably identify and supply relevant competencies, such as ecodesign, recyclability assessment, or circular materials processing. Limited export readiness for compliant formats prevents converters from credible positioning in the EU market, while incomplete regulatory alignment with EU packaging law and weak enforcement are further eroding investment signals. And finally, underdeveloped green public procurement for sustainable packaging is missing an opportunity to anchor early demand and accelerate market normalization.

***Recommendations**: PPWR and single-use plastic (SUP) implementation roadmap (Rec. 4.11); eco-modulated extended producer responsibility (EPR) (Rec. 4.12); packaging compliance coordination cell (Rec. 4.13); converter feedstock qualification (Rec. 4.14); guarantee-backed lending (Rec. 4.15);*

supplier-development services (Rec. 4.16); export development package (Rec. 4.19); business support institutions (Rec. 4.21). The analytical underpinnings for the sector-level recommendations for the plastic packaging market are described in greater detail in the sector assessment deliverable (World Bank, forthcoming-a).

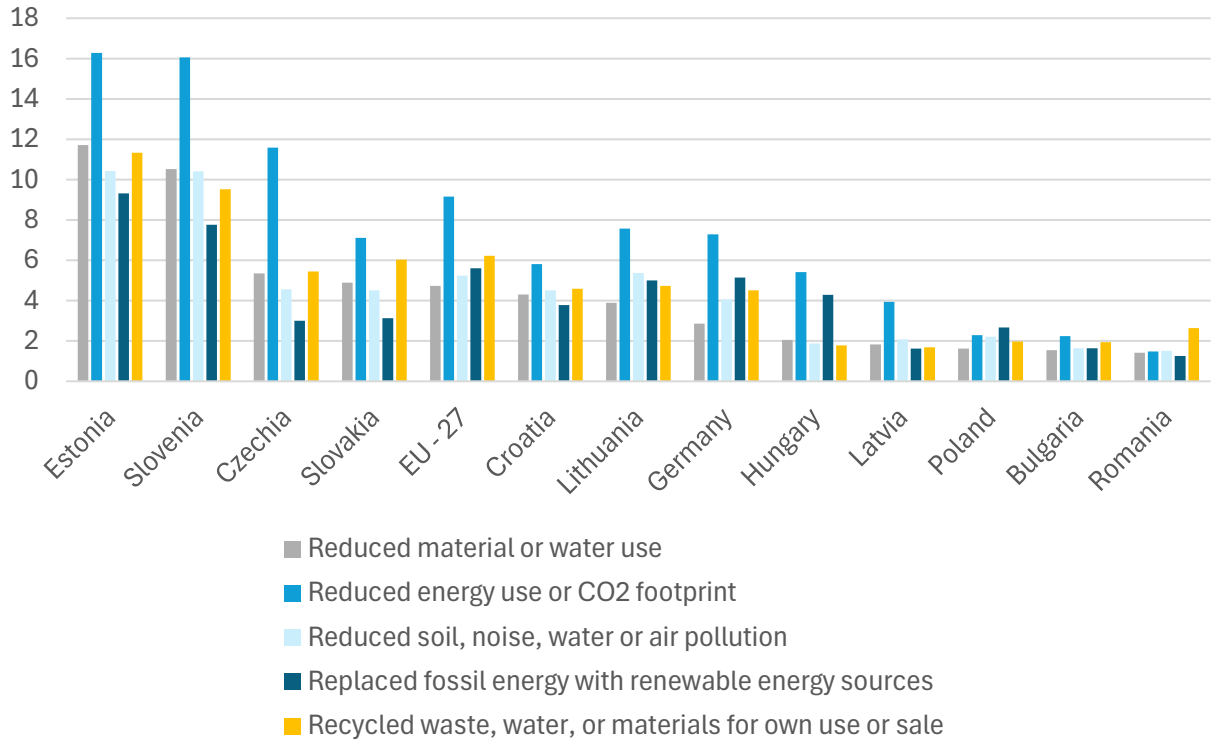
Key finding 5: The underlying innovation ecosystem is weak, with environmental regulations playing almost no role in driving firm-level R&D.[37]

Romania's innovation performance is the lowest in the European Union by a significant margin, constituting a key barrier to value chain integration across sectors (World Bank 2025a). Its 2024 European Innovation Scoreboard score stands at just 34 percent of the EU average, and this score is lower than in 2023, meaning the gap is widening rather than closing. Results show structural weaknesses related to chronic underfunding, shortage of skilled human resources, poor academia-business linkages, and large regional disparities in innovation capacity.

The role of environmental regulation in stimulating innovation is particularly weak, indicating a structural disconnect between the regulatory environment and the innovation decisions of firms. Only 11 percent of Romanian firms introduced any innovation in 2020, against an EU average of 53 percent (World Bank 2025a). The share is even lower for green innovation—only about 1-3 percent of firms report innovations with significant environmental benefits across most categories (Figure 18), with a slightly higher share in recycling waste, water, or materials for own use or sale. And only 1.9 percent of Romanian firms initiated an innovation project because of environmental regulations in 2020 (Figure 19), the lowest rate in the peer group (Croatia: 7.3 percent, Estonia: 7.1 percent, Bulgaria: 4.1 percent, Poland: 3.2 percent). Romania is ranked 22nd on the EU Eco-Innovation Index (2024) on the number of eco-innovation patents ("green patents"), which cover environmental technologies (European Commission n.d.). The country's overall performance on the index deteriorated between 2014 and 2022, while the EU average improved over the same period. Between 2011 and 2022, Romania filed a total of 166 international patents (the lowest per capita in the EU), of which fewer than 8 percent (13 patents) were classified as green. The environmental patent intensity, at less than 1 invention per million people in 2023, is far below the EU average, while the relative share of green patents on environmental technologies is 6 percent and closer to peer countries, suggesting a scale, rather than a specialization problem. Despite a gradual increase over time, the number of academic publications associated with eco-innovation stands at about half of the EU average. The country performs relatively well in the number of ISO 14001 certificates (the international standard for Environmental Management Systems), which reflects the level of environmental awareness and management capability of businesses, but recent data reflects an abrupt declining trend.

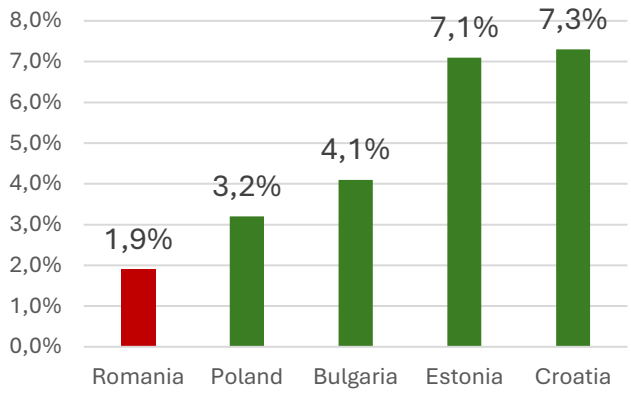
[37] This key finding is derived from World Bank (2025a). Please refer to Annex 1 b) for a detailed methodology.

Figure 18 Only 1-3 percent of firms in Romania introduced innovations with significant environmental benefits within the enterprise from 2020-2022



Source: World Bank calculations, based on Eurostat 2024 and Eurostat 2026.

Figure 19 Only 11 percent of firms in Romania initiated an innovation project due to environmental regulations in 2020



Source: World Bank calculations, based on Eurostat 2022.

When regulation does not create credible compliance pressure, public R&D subsidies must carry the entire burden of stimulating green innovation, and they are currently too small and poorly structured to do so. Romania allocates about 4 percent of total government R&D funding to

environmentally related R&D, which is higher that the EU average of 2.4 percent. However, Romania's R&D funding, as share of GDP is chronically low and much lower compared to its peers, from both public (0.46 percent) and private sources (0.29 percent), among the lowest in the EU. The country's markets for green bonds, equity, and private equity/venture capital are also underdeveloped. The policy mix assessment found that the research and innovation (R&I) financing portfolio envelope is €1.109 billion (11 percent), but many instruments combine green with digital and semiconductor objectives, making the green share impossible to track separately in current reporting systems. The majority of direct R&I support flows to Public Research Institutions (PRIs) rather than to the private firms that would translate research into commercial green products. The planned allocations for smart specialization (S3) and Strategic Technologies for Europe Platform (STEP) investments reach about €5 billion, but concrete national targets for green technology are still missing. Romania is still a laggard in Horizon Europe (HE) funding: by mid-2026, the net EU contribution for Romanian participants reaches only 0.63 percent of total HE funds, much lower than peer countries.

Recommendations: *R&I and smart specialization (Rec. 4.22); demand-side policies (Rec. 4.24)*

Key finding 6: Green jobs require higher levels of skills that are already in short supply in Romania.[38]

Availability of skilled labor is another critical fundamental that presents a barrier to green competitiveness in Romania (World Bank 2025a). High levels of skills shortages and mismatches in Romania, due to one of the highest migration rates in the EU and challenges in the education system, reduce the country's innovation capacity and present challenges to green growth (IFC 2023). At a sectoral level, 51 percent of industrial companies were suffering from skills shortages (IFC 2023). Science, technology, engineering, and mathematics (STEM) knowledge and abilities—which tend to require greater numeracy, literacy, and problem-solving skills than the Romanian average—are especially sought-after skills in the green transition, in addition to language proficiency, active listening, and design skills. World Bank analysis based on artificial intelligence (AI) and machine-learning tools indicates that offers for green jobs account for 9 percent of all job postings on the Romanian labor market (World Bank 2023a) and are expected to increase. Among the identified vacancies, only a minority are jobs that require short retraining to transition to a green occupation, while most require significant retraining and fundamentally new skills to transition into green jobs. This highlights the need for long-term retraining programs to reskill workers and enable them to transition to green jobs (World Bank 2023b).

Recommendations: *green skills partnerships (Rec. 4.17)*

Key finding 7: Despite this potential, the policy mix is neither funded at the scale nor structured in the way needed to address the fundamentals and catalyze value chain integration.[39]

[38] This key finding is derived from World Bank 2025a. Please refer to Annex 1 b) for a detailed methodology.
[39] This key finding is derived from World Bank 2025a. Please refer to Annex 1 b) for a detailed methodology.

Value chains and SME development receive just 6 percent of the total portfolio (approximately €622 million), compared to 23 percent for renewables and 21 percent for energy cost shields (World Bank 2025a). The principal instrument, Just Transition "Productive Investments for SMEs" (€775.5 million), is geographically limited to six coal-dependent counties, leaving the value chain opportunity largely unaddressed at the national level. Green skills receive only 0.2 percent of the portfolio (€20 million), despite 51 percent of industrial companies reporting skills shortages and green jobs already representing 9 percent of all employment. Most green job vacancies require new skills rather than short-term retraining, a structural gap that cannot be closed at €20 million. The MSME financing gap is estimated at 26 percent of GDP, with 14 percent of SMEs fully or partially credit-constrained and loan rejection rates at 22.5 percent, nearly three times the Europe and Central Asia average.

Recommendations: *supplier-development services (Rec. 4.16); green skills partnerships (Rec. 4.17); guarantee-backed transition finance (Rec. 4.18); R&I and smart specialization (Rec. 4.22); MSME access to finance (Rec. 4.23)*

Key finding 8: The potential of Green Public Procurement to drive sustainability transitions is underutilized[40]

While Romania's formal framework for green public procurement (GPP) is relatively advanced, its implementation is weak and undermines a key demand-side policy tool to drive systematic energy efficiency adoption (World Bank, forthcoming-e). The lack of a national monitoring tool, dedicated training toolkit, and certification systems for suppliers or products means that provisions are rarely translated into meaningful practice. Authorities technically can include energy efficiency requirements in procurement procedures, but they rarely do so due to a lack of qualified staff and limited technical capacity. Where energy efficiency criteria are used, more often in tenders financed by EU funds than national budgets, they are frequently applied in a formalistic way (e.g., bidders provide written statements of compliance that are not verified). Contracting authorities struggle to prepare terms of reference that reflect Best Available Technology (BAT) or to appropriately weight energy efficiency in evaluations, resulting in inconsistent application across institutions. Procurement officials also face insufficient training opportunities, poor cross-agency coordination, and strong persistence to award based on lowest price. The absence of a supplier certification system further increases transaction costs, as procurers lack a reliable mechanism to identify credible green products. These issues are reflected in experts' assessment, with particularly high concerns around inconsistent implementation across agencies, overemphasis on lowest price, and insufficient training.

Recommendations: *demand-side policies (Rec. 4.24); structured public-private dialogues (Rec. 4.20)*

[40] This key finding is derived from World Bank (forthcoming-e).

Table 3 Key short-term recommendations – Green Competitiveness

Area	**Short-term actions**	**Key Finding(s)**
Electric Vehicle Batteries and Stationary Storage	**4.1 Grid-fee exemption for storage**: Reform tariff rules to eliminate double network charging for stored electricity.	Key Finding (KF) 2
	4.2 Five-year storage procurement plan: Establish a five-year storage procurement plan through the national transmission operator.	KF 2
	4.3 Fast-track permitting for BESS installations: Reduce administrative delays and unpredictability in project execution to improve investor confidence and accelerate deployment.	KF 2
	4.4 Export and FDI promotion: Launch strategic and well-targeted FDI and export promotion to boost Romania's capacity to compete globally.	KF 1, 2
	4.5 Financial sector readiness and bankability framework: Standardize risk documentation and make public guarantees conditional on lender preparedness to unlock finance for commercially viable projects that currently cannot reach financial close.	KF 2
	4.6 Loan guarantees for BESS batteries manufacturing: Provide state guarantees of up to 70–80 percent of debt for BESS manufacturing, integration, and recycling projects, with long tenors and risk-based pricing, to crowd in private bank financing.	KF 2
Wind Energy	**4.7 Rolling CfD auction calendar with grid-ready sequencing:** Establish a predictable, multi-year pipeline of wind auctions - without it, developers, lenders, and suppliers cannot plan ahead, and downstream investments will not materialize.	KF 3
	4.8 EU-compliant non-price auction criteria and delivery discipline: Refine wind auction design to include a more operational set of non-price criteria that remain open to EU-wide competition.	KF 3
	4.9 Wind delivery unit and digital case-tracking protocol: Establish a small delivery unit with a clear mandate to track milestones, escalate bottlenecks, and assign lead case managers to eligible projects, allowing announced investments to move from award to actual delivery.	KF 3
	4.10 Supplier qualification and OEM readiness program: Launch a structured supplier development program combining firm diagnostics, gap assessments, and certification support to prepare Romanian firms to compete for contracts in both local and regional markets.	KF 3
Plastic Packaging	**4.11 PPWR and SUP implementation roadmap and guidance package:** Establish a single roadmap through 2030 with standard guidance for industry and inspectors - without a clear, sequenced national implementation path, firms cannot make rational investment decisions.	KF 4

	4.12 Eco-modulated EPR and compliance enforcement upgrade: Strengthen the EPR system to differentiate credibly between packaging types and improve registry discipline and market surveillance, creating the market pull that gives firms a commercial reason to invest in compliance.	KF 4
	4.13 Packaging compliance coordination cell: Establish a small coordination cell tasked with cross-checking compliance data, escalating enforcement cases, and tracking delivery of core transition actions to ensure policy intentions translate into practice.	KF 4
	4.14 Converter feedstock qualification and trial support: Provide technical assistance and a traceability support mechanism to support structured qualification trials between recyclers, Deposit Return System actors, and converters, improving feedstock reliability and reducing qualification costs.	KF 4
	4.15 Guarantee-backed lending and concessional finance: Provide guarantee-backed lending for viable circular-packaging investments and establish a concessional finance window for converter investments facing long payback periods or elevated transition risk, with eligible uses linked directly to converter modernization.	KF 4
Horizontal (Transversal) Policy Options	**4.16 Supplier-development and investment-readiness services:** Develop a targeted supplier-development mechanism combining diagnostics, engineering audits, compliance toolkits, buyer-linkage support, and project-preparation assistance for SMEs and mid-caps, seeking synergies with export development actions where off-takers are multinationals or regional firms.	KF 2, 3, 4
	4.17 Sector-configurable green skills partnerships: Create a performance-based grant mechanism for education and training suppliers, embedded in sector partnerships that define and regularly update occupational needs, with funding linked to verified industry demand and performance indicators such as job placement and firm uptake.	KF 6
	4.18 Guarantee-backed and concessional transition finance: Provide guarantee-backed lending and concessional transition finance through existing financial intermediaries, supported by development finance institutions-backed risk-sharing windows, targeting collateral and credit-risk constraints.	KF 7
	4.19 Export development and trade-support package for compliance-sensitive sectors: Strengthen and target export development services combining market intelligence, buyer discovery, compliance-positioning support, and export advisory (in combination with A5).	KF 2, 3, 4

	4.20 Structured public-private dialogues for policy refinement: Create a structured public-private dialogue platform with defined participation rules, a focused agenda, and a formal link to policy review cycles, providing technical feedback and market intelligence without replacing formal decision-making.	KF 7
	4.21 Business support institutions: Support the development of institutions, such as business development service providers, certification bodies, quality assurance service providers, and others, to support firms to compete in new markets.	KF 3, 4
	4.22 Research and innovation and smart specialization: Increase the focus of existing programs on green objectives with dedicated funding calls and clear budget earmarks. Establish transparent performance benchmarks to monitor, evaluate, and improve the effectiveness of R&I expenditure, ensuring alignment with sustainability goals.	KF 5
	4.23 MSME access to finance: Address the MSME financing gap through dedicated green credit lines and guarantee schemes designated for smaller firms seeking to invest in the capabilities needed for value chain integration.	KF 7
	4.24 Demand-side policies: Strengthen environmental regulatory standards, including product requirements and emissions limits for industrial installations to create a market pull for green innovation.	KF 5, 8

Note: BESS = Battery energy storage systems; CfD = contract-for-difference; EPR = Extended producer responsibility; FDI = foreign direct investment; MSME = Micro-, small and medium-sized enterprises; OEM = original equipment manufacturers; PPWR = Packaging and Packaging Waste Regulation; SMEs = small and medium-sized enterprises; SUP = single-use plastic.
Source: World Bank.

5. Private sector climate adaptation

Public sector support for private sector climate adaptation can counteract the significant risks posed by the effects of climate change on firm productivity and competitiveness across different sectors. Physical climate risks can be due both to the intensification of natural disasters, as well as slow processes, such as temperature and sea level rise, and can threaten firms' productivity and income through business disruptions, supply chain interruptions or property and asset damages. Investment in adaptation is critical for building resilience and remaining competitive and can have significant positive externalities across sectors and value chains. However, firms often underinvest due to lack of information, uncertain, intangible, or distant benefits, challenges in accessing finance for adaptation or insurance, and other market and governance failures.

Romania is the most climate-vulnerable country among its regional peers, with a significant share of its economic output generated in areas directly exposed to flooding and extreme heat. Flooding is the dominant hazard, causing approximately €1.7 billion in potential annual damages to critical infrastructure and an estimated €156 million annually in business interruptions, of which 37 percent is directly attributable to climate change intensification rather than baseline weather variability (World Bank 2024a; World Bank, unpublished). These risks are not evenly distributed across the country: southern and southeastern regions face high drought risks, while western and central areas are more exposed to flooding and landslides. The concentration of economic activity in high-risk zones amplifies the systemic nature of the threat. In 2023, non-financial corporations operating in flood-vulnerable areas generated 12.7 percent of aggregate gross value added, while those in extreme heat risk zones contributed 10.4 percent. Climate shocks are therefore not peripheral disruptions but a direct threat to a significant share of Romania's productive capacity.

Key finding 1: Romanian firms face high climate exposure with very limited investment in adaptation measures.[41]

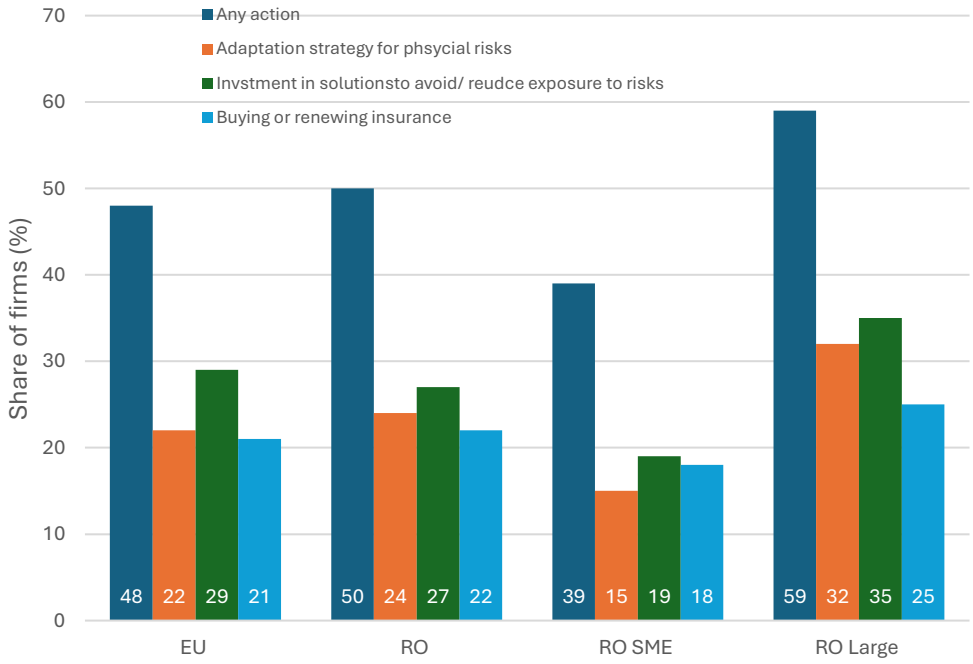
Private sector awareness of climate risk remains low, and adaptation investment is limited, despite Romania's high exposure (World Bank 2025a). Only 23 percent of Romanians consider climate change a "very serious" issue, roughly half the EU average. Just 39 percent of SMEs have undertaken any adaptation measures, compared to 59 percent of large firms (Figure 20). Firms with dedicated risk management functions, access to capital markets, and international exposure are more likely to invest in adaptation; the majority of Romania's SME population lacks these capacities and remains largely unprepared. Fewer than 25 percent of business assets are covered by any form of climate-related insurance, and more than half of firms report that existing products are unaffordable or inaccessible.

Despite recording among the high climate-related economic losses in the EU, most Romanian firms have no financial protection against those losses. Averaging 0.15 percent of GDP annually

[41] This key finding is derived from World Bank (2025a). Please refer to Annex 1 b) for a detailed methodology.

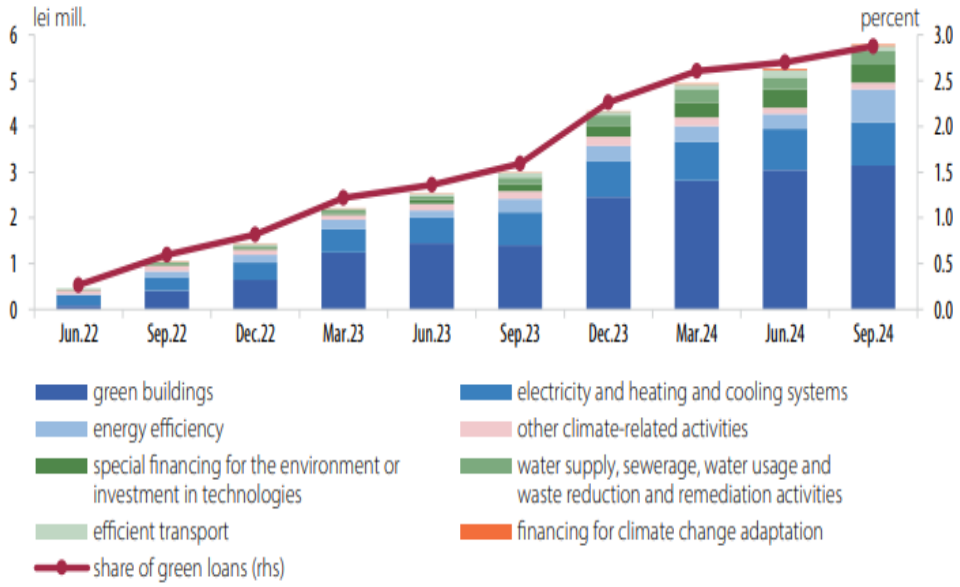
in climate-related losses, Romania ranks fifth in the EU for uninsured damages, and only 22 percent of firms report having any insurance against climate-related losses. Romanian firms, especially SMEs, rely overwhelmingly on internal cash flows and retained earnings, with limited access to bank credit and virtually no use of financial hedging instruments. While overall green lending has increased from less than 0.5 percent in 2022 to 3 percent in 2024, Romanian banks have seen limited uptake in loans explicitly dedicated to climate adaptation projects (Figure 21) (NBR 2024). A climate shock that disrupts revenue streams or damages physical assets therefore leaves most firms without a viable path to recovery without external support. Low insurance penetration, shallow financial intermediation, and high physical exposure together create a systemic vulnerability that the current policy framework leaves unaddressed.

Figure 20 Only 39 percent of SMEs have undertaken adaptation measures in 2024 compared to 49 percent of large firms



Source: EIB 2025.

Figure 21 The share of climate adaptation financing in the overall green lending portfolio remains limited



Source: NBR 2024.

Recommendations: *expand SME insurance coverage (Rec. 5.3); invest in climate risk data (Rec. 5.6)*

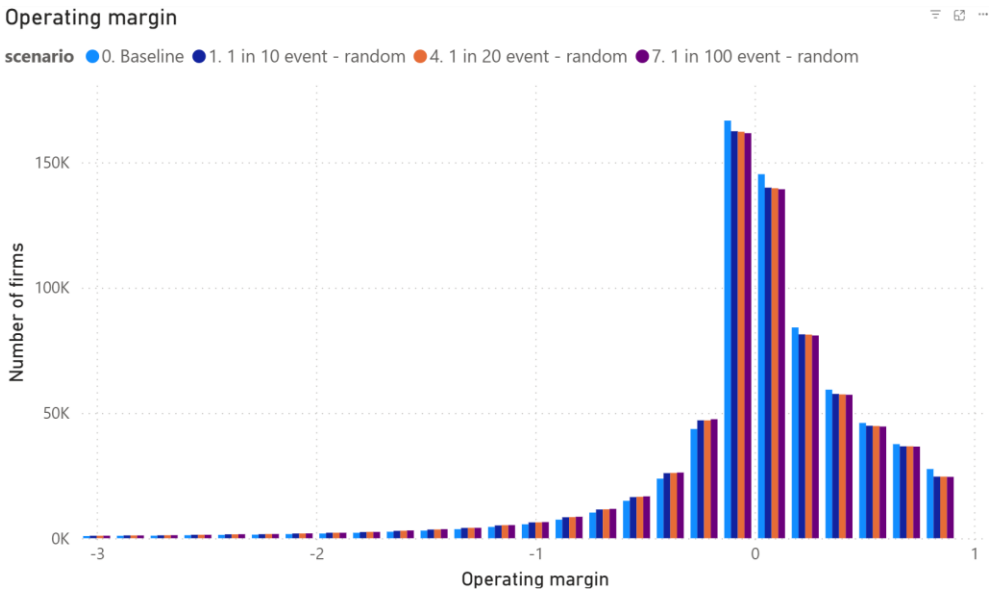
Key Finding 2: A severe flood event would cause significant, measurable damage to firm profitability, liquidity, employment, and public revenues.[42]

Stress-testing against a 1-in-100-year flood scenario reveals that a single major event could push tens of thousands of firms into financial distress, with cascading effects on employment and public revenues (World Bank, forthcoming-b). Approximately 23,000 profitable firms would become unprofitable (Figure 22), a 4.4 percent decline in the total number of profitable firms across the economy. The number of firms facing acute liquidity shortages would rise by 13 percent, reflecting the speed at which cash flow disruptions escalate when firms have no pre-arranged financing in place. Roughly 25,305 jobs would be put directly at risk, with the indirect employment effects likely significantly higher once supply chain disruptions and reduced local spending are considered. Corporate tax revenues would fall by approximately €194 million, equivalent to 5.7 percent of the baseline, a loss that would directly constrain public sector capacity to fund the recovery response.

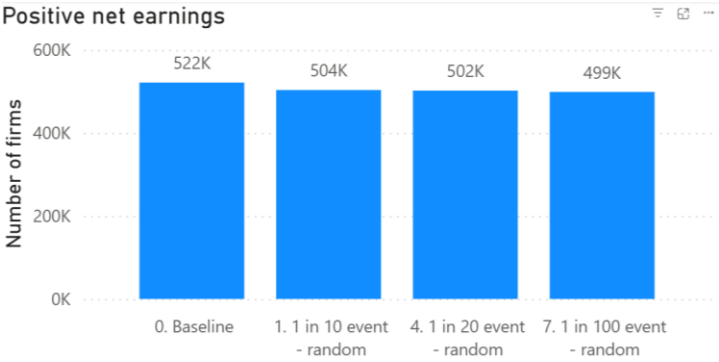
[42] This key finding is derived from World Bank (forthcoming-b). Please refer to Annex 1 e) for a detailed methodology.

Figure 22 In a 1-in-100 year flood scenario, 23,000 profitable firms would become unprofitable

(a) Distribution of operating margin



(b) Number of firms with positive net earnings



Source: World Bank calculations.

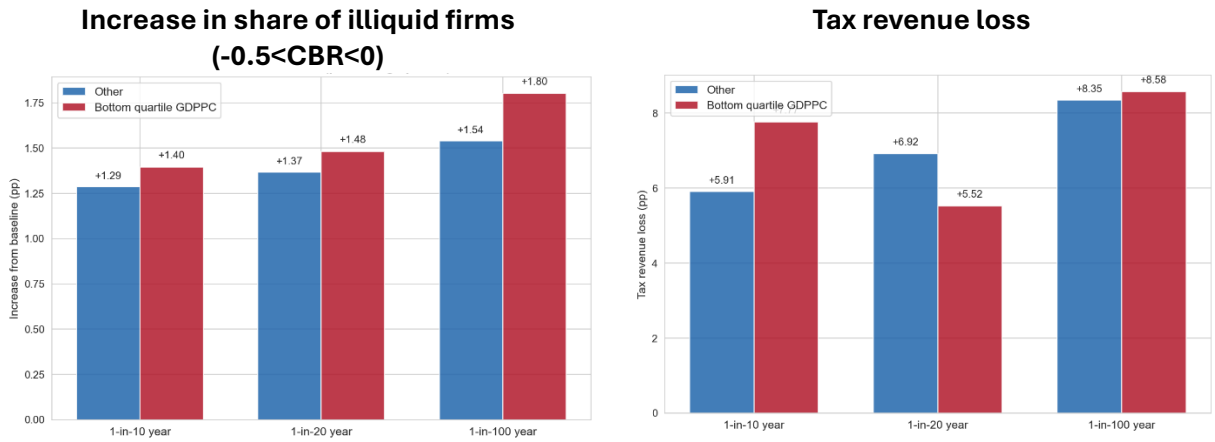
A 1-in-100-year flood is a realistic near-term scenario, not a remote worst case. Under current climate trajectories, the frequency of such events is increasing, and Romania has already experienced major flood events in recent decades. The stress test results therefore represent plausible outcomes rather than distant projections. The aggregate impact on the banking sector appears limited, partly because Romanian firms do not rely heavily on bank credit; the firm-level impact on liquidity and survival, however, is severe and concentrated among firms with the least capacity to recover.

***Recommendations**: National Financial Resilience Strategy (Rec. 5.1); Industry Resilience Window under PCG (Rec. 5.2); prioritize adaptation for most exposed sectors (Rec. 5.4)*

Key Finding 3: The burden falls disproportionately on economically lagging regions and vulnerable sectors.[43]

Aggregate national figures mask severe local concentrations of climate risk that have direct implications for regional equity and economic cohesion (World Bank, forthcoming-b). In counties such as Giurgiu, Galați, and Călărași, already among Romania's most economically fragile with below-average incomes, higher unemployment, and weaker public finances, local tax revenue losses under a severe flood scenario could reach 18 to 20 percent of the baseline (Figure 23). For local governments with limited fiscal buffers, this scale of loss would be devastating, simultaneously reducing the resources available for recovery at precisely the moment when demand for public services is highest.

Figure 23 The impact of a severe flood scenario would be significantly worse in counties that are already economically fragile



Source: World Bank calculations.

Note: CBR = cash burn rate.

The sectoral distribution of climate risk further concentrates the burden on sectors that are already under structural pressure. The largest increases in emergency funding needs following a shock fall on Manufacturing, Construction, Wholesale and Retail Trade, and Agriculture. These sectors are asset-intensive, with physical infrastructure directly exposed to flood damage; they depend on uninterrupted supply chains vulnerable to localized disruptions; they operate on thin profit margins; and they are the primary employers in many high-risk regions. A climate shock affecting these sectors in already fragile counties simultaneously reduces private sector viability and local public revenues, a compounding effect that aggregate national figures do not fully capture.

***Recommendations**: prioritize adaptation for most exposed sectors (Rec. 5.4); targeted support for lagging counties (Rec. 5.7)*

[43] This key finding is derived from World Bank (forthcoming-b). Please refer to Annex 1 e) for a detailed methodology.

Key finding 4: The current portfolio mix of financing instruments targeting firms does not support private sector climate adaptation.[44]

The most significant structural gap in Romania's policy landscape is the complete absence of instruments supporting private sector climate adaptation (World Bank 2025a). Of the 34 instruments in Romania's current policy portfolio, totaling €10 billion, none are dedicated to private sector climate adaptation. The portfolio is concentrated on decarbonization (62 percent) and competitiveness (38 percent), leaving adaptation entirely unaddressed despite Romania's elevated physical risk profile. Romania has several mechanisms in place that are relevant to climate change adaptation, such as insurance frameworks and climate-resilient crop production incentives, but none are designed to help firms manage or recover from physical climate risks. The recently approved National Strategy on Adaptation to Climate Change 2024-2030 (Government of Romania 2024) includes provisions that would support some aspects of firm adaptation, including promoting insurance as a key mean for climate adaptation, developing climate risk management tools for vulnerable sectors, and establishing farmers' mutual insurance companies under favorable conditions to provide tailored risk-sharing mechanisms. Closing this gap requires a deliberate reorientation of Romania's support architecture toward ex ante resilience, alongside the existing decarbonization and competitiveness objectives.

Recommendations: *National Financial Resilience Strategy (Rec. 5.1); Industry Resilience Window under PCG (Rec. 5.2); expand SME insurance coverage (Rec. 5.3)*

Key Finding 5: The current policy response is reactive and ad hoc, leaving firms exposed before and during a disaster.[45]

Romania's disaster response mechanisms are structured around post-event relief rather than pre-arranged resilience, making them both costlier and less effective than proactive alternatives (World Bank, forthcoming-b). Emergency liquidity support is mobilized only after a disaster has caused damage, credit is extended under pressure without pre-agreed terms, and insurance claims, where they exist, take months to process. There are no pre-arranged contingency funds, no credit guarantee windows dedicated to disaster preparedness, and no structured incentive for firms to invest in business continuity planning (BCP) before a shock occurs.

Post-event relief is both more expensive and less targeted than pre-arranged resilience instruments. Resources mobilized after a disaster are deployed under fiscal stress and time pressure, with limited capacity to direct support toward the firms most in need. The cost of post-disaster support consistently exceeds the cost of equivalent pre-arranged instruments, since the state bears the full financial burden without the risk-pricing or risk-reduction conditions that structured ex ante mechanisms provide. Ad hoc government support after a disaster also reduces

[44] This key finding is derived from (World Bank 2025a). Please refer to Annex 1 b) for a detailed methodology.
[45] This key finding is derived from World Bank (forthcoming-b). Please refer to Annex 1 e) for a detailed methodology.

firm incentives to invest in preparedness, a moral hazard that reinforces continued underinvestment in resilience.

Recommendations: *National Financial Resilience Strategy (Rec. 5.1); integrate business continuity planning (BCP) as eligibility requirement (Rec. 5.5)*

Key Finding 6: Modeling estimates of required funding indicate a significant financing gap between expected losses, emergency response needs, and available assistance.[46]

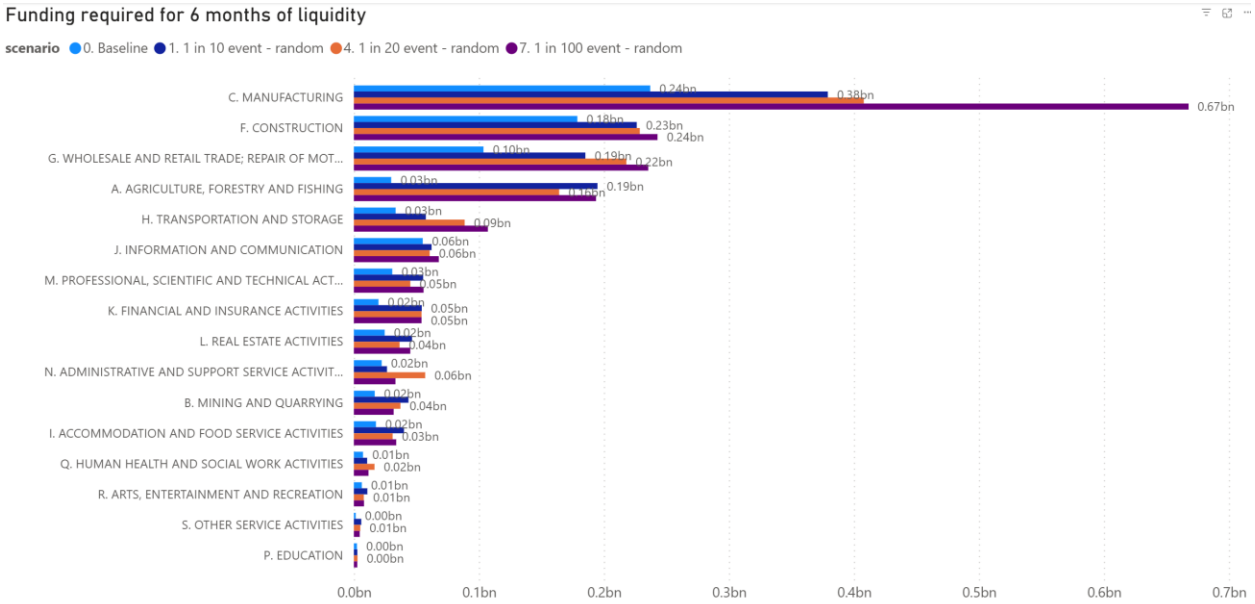
To assess potential government support needs, the simulation analysis estimated the funding required to help firms overcome short-term liquidity distress (World Bank, forthcoming-b). Distressed firms are defined as those with a cash burn rate (CBR) ranging between -0.5 to 0, indicating cash reserves would be depleted within half a year. The funding envelope is limited to a subset of "viable" firms, those deemed to have higher survival likelihood with temporary support.[47]

Total funding requirements increase substantially under the 1-in-100-year scenario to €1.8 billion (a more than 128 percent increase) with the biggest increase concentrated in four sectors (Figure 24):

- Manufacturing: €0.67 billion (a nearly threefold increase from €0.24 billion)
- Construction: €0.24 billion (up from €0.18 billion)
- Wholesale and retail trade: €0.22 billion (up from €0.1 billion)
- Agriculture: €0.19 billion (up from €0.03 billion—more than sixfold increase)

[46] This key finding is derived from World Bank (forthcoming-b). Please refer to Annex 1 e) for a detailed methodology.
[47] Viable firms are defined as firms with at least five employees, with a ratio of net debt to earning before tax less than 4 or an operating profit margin greater than 1 percent.

Figure 24 In a 1-in-100-year flood scenario, up to €1.8 billion would be required for six month liquidity



Source: World Bank calculations.

Funding requirements are also geographically dispersed. Projected total required funding are the highest in Bucharest, Ilfov, Timiș, and Constanța, a result of both higher firm concentration and vulnerability to flooding. In relative terms, the funding burden as a share of local GDP are highest in Tulcea, Constanța, Ilfov, Călărași and Galați (between 1.8 to 2.8 percent county's GDP). Overall, lower income counties (the bottom quartile in GDP per capita) face a larger increase relative to their local economy, especially in worst-case scenarios. The additional funding required for short term liquidity support for viable firms in a 1-in-100 year flood event (compared to baseline) are 1.2 times higher in these counties than in other counties.

Recommendations: *Industry Resilience Window under PCG (Rec. 5.2); targeted support for lagging counties (Rec. 5.7)*

Key finding 7: Estimate suggest that credit guarantees is a cost-effective approach to covering the funding gap.[48]

Modeled interventions demonstrate that a shift toward ex ante resilience instruments is not only feasible but fiscally attractive, with contingent costs as low as 10 to 25 percent of equivalent direct relief expenditure (World Bank, forthcoming-b). Strengthening firms' financial resilience to disasters requires a shift from predominantly ex post support toward a more balanced approach that integrates ex ante financial preparedness across sovereign, firm, and financial-sector levels. At the sovereign level, managing the fiscal and economic impacts of disasters requires moving beyond ad hoc emergency budgetary allocations toward ex ante financial instruments.

[48] This key finding is derived World Bank (forthcoming-b). Please refer to Annex 1 e) for a detailed methodology.

A layered approach combining credit guarantees, expanded insurance coverage, and business continuity requirements could shift Romania toward a fiscally sustainable resilience model built on existing institutions. Some of the benefits of ex-ante instruments include faster and predictable disbursement, reducing operational downtime and accelerating recovery for affected businesses, lower fiscal volatility, limiting the need for large, unplanned budget reallocations, and avoiding potential losses of tax revenue, reducing liquidity distress for firms with rapid fiscal support, improved value for money by pricing risk ex ante through insurance premium and contingent credit fees, and job and investment protection.

Recommendations: *Industry Resilience Window under PCG (Rec. 5.2); expand SME insurance coverage (Rec. 5.3)*

Table 4 Key short-term recommendations - Private Sector Climate Adaptation

Area	Short-term actions	Key Finding(s)
Cross-cutting / Policy framework	**6.1 Develop a National Financial Resilience Strategy** that explicitly includes an SME pillar, linking sovereign, household, and firm-level resilience mechanisms and establishing pre-arranged financing instruments (contingency funds, contingent credit lines).	Key Finding (KF) 4, 5
Finance / Credit guarantee schemes	**6.2 Create a dedicated "Industry Resilience Window"** under existing SME Partial Credit Guarantee (PCG) schemes to provide guarantees for lending explicitly tied to disaster preparedness and climate adaptation investment.	KF 6, 7
Insurance	**6.3 Expand SME coverage under the Pool Against Natural Disasters (PAID) program** by enabling bundled loan-and-insurance products; develop specialized, affordable insurance products for climate-related business interruption risks.	KF 1
Manufacturing, Construction, Wholesale/Retail, Agriculture	**6.4 Prioritize adaptation support instruments for the four most financially exposed sectors**, including targeted liquidity facilities and sector-specific business continuity guidance.	KF 3, 6
SMEs / Business environment	**6.5 Integrate business continuity planning (BCP) as an eligibility requirement for financial support** instruments, following Japan's model, to incentivize proactive firm-level risk management.	KF 5
Data and risk modeling	**6.6 Invest in improved climate risk data**, particularly for extreme heat and drought, to enable better financial impact assessment and more targeted instrument design.	KF 1

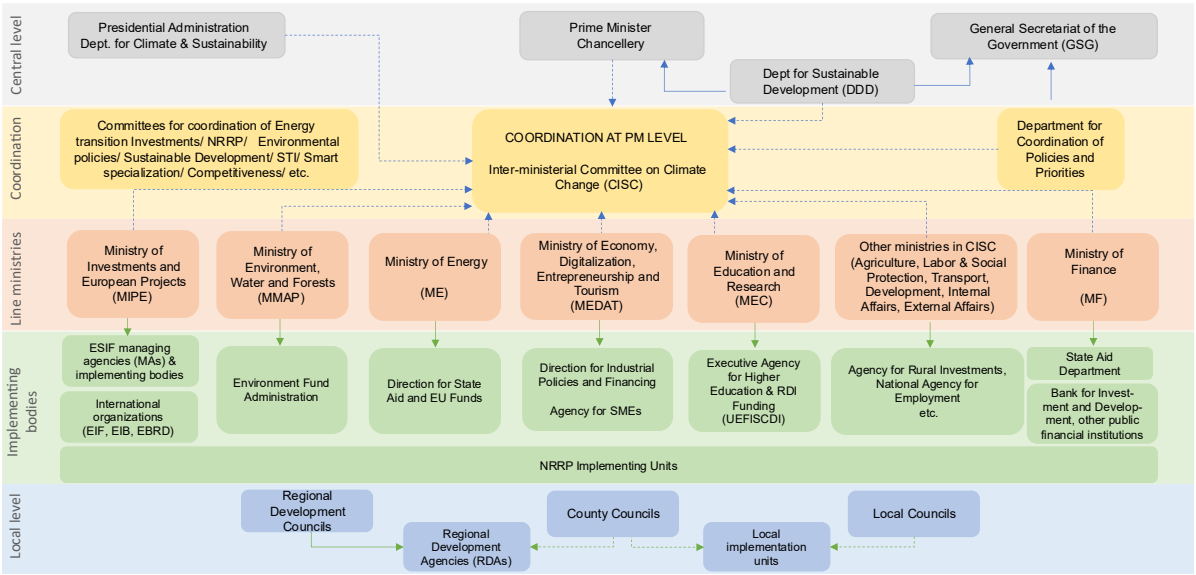
Regional policy	**6.7 Apply heightened targeting of adaptation instruments toward economically lagging counties** with disproportionate flood exposure (e.g., Giurgiu, Galați, Călărași), where local fiscal and employment impacts of climate shocks are most severe.	KF 3

Note: SME = small and medium-sized enterprise.
Source: World Bank.

6. Governance

Romania's approach to governance and coordination of climate action is 'whole-of-government', developed organically in an interlinked legal, policy, and institutional framework across different levels of government involved in various parts of the climate agenda. Romania's international commitments, especially its obligations linked to accessing external resources (i.e., EU funds), have been a primary driver in creating new institutional structures or progressively adding specific mandates and competencies to existing institutions at the central and local levels. This multi-level governance arrangement, which covers topics beyond greening of the private sector, includes (i) inter-institutional coordination at the central level, (ii) national-level ministerial mandates that have primarily sectoral focus, and (iii) sub-national initiatives that can be regional or local (Figure 25). More granular data and analysis of Romania's policy and strategic framework for climate change and participation in EU and international green transition commitments and initiatives can be found in the GRIN Policy Mix deliverable (World Bank, 2025a).

Figure 25 The whole-of-government framework for climate action and competitiveness governance is multi-level



Source: World Bank.

Key finding 1: Romania's green transition governance is growing more complex without growing more coordinated.[49]

Romania's multi-layered institutional architecture for the green transition is, in operational practice, deeply fragmented, with coordination between bodies producing the lowest score in the functional assessment (World Bank 2025a). The governance landscape spans the Presidential Administration, the Prime Minister's Chancellery, the Department for Sustainable Development, the

[49] This key finding is derived from World Bank (2025a). Please refer to Annex 1 b) for a detailed methodology.

Inter-Ministerial Committee on Climate Change (CISC), the Ministry of Investments and European Projects (MIPE), and multiple line ministries (Energy, Environment, Economy, Research, Finance), each with implementing agencies and regional bodies. Functional assessment of 13 key instruments (totaling €3.4 billion) reveals mean scores of 2.8/5 for design, 2.9/5 for implementation, and 2.7/5 for governance, with governance the worst-performing dimension, putting 90 percent of assessed funds at risk. The "Programs Relationship" sub-indicator (the degree of coordination with related programs) scored just 2.3/5, the single lowest score in the entire assessment. "External Constraints" (exposure to State aid, procurement, and audit rules outside program managers' control) scored 2.0/5. Overall, 92 percent of funds are associated with instruments rated as having governance challenges. Most instruments operate in institutional silos without formal mandates to coordinate across boundaries; and the CISC, while formally established, has not translated its coordination mandate into the working-level alignment needed to identify complementarities or avoid duplication.

Regulatory enforcement is a specific and serious dimension of the governance failure, now formally documented by the European Commission. Legislation mandating energy audits for large enterprises is widely considered too vague to be enforceable; ANRE maintains a registry of energy auditors but lacks consistent information-gathering on implemented measures. The gap between legal obligation and operational compliance is so material that the European Commission issued Romania a formal infringement notice in June 2025 for failing to ensure effective market surveillance and compliance with EU Ecodesign and energy labeling regulations. Romania has also not deployed a central Energy Efficiency Obligation (EEO) scheme committing utilities to annual efficiency gains, relying instead on alternative measures that best-practice benchmarking characterizes as "fragmented."

Data governance represents the most acute operational weakness in the entire portfolio, rendering 82 percent of instruments unable to assess their own effectiveness. The "Program Databases" indicator scores 2.2/5, the most pronounced single weakness in the functional assessment. Most instruments rely on MS Office spreadsheets and email for data collection and reporting. Firms submit energy data via complex spreadsheets or scanned PDFs unsuitable for aggregation and analysis. Reporting is perceived as a compliance exercise rather than a tool for policy development: sector benchmarks are scarce, complicating peer comparison; publicly available data are often not detailed enough for targeted interventions or are published with significant delays; and 65 percent of launched programs do not disclose contracted amounts. At the instrument level, 9 out of 11 analyzed instruments (82 percent) were found unable to effectively measure their own success, lacking theories of change and not tracking energy savings or emissions reductions as outcomes, with M&E frameworks focused on administrative disbursement compliance rather than investment effectiveness. Poland scores 3.8/5 on "learning during implementation" versus Romania's 2.8/5; Israel's Innovation Agency is the international benchmark for merit-based fund allocation with robust M&E.

Recommendations: *standardize application procedures (Rec. 6.1); resource ANRE enforcement (Rec. 6.3); publish sector benchmarks (Rec. 6.4); annual operational audits (Rec. 6.5);*

implementation audit (Rec. 6.6); single integrated monitoring framework (Rec. 6.7); upgrade CISC mandate (Rec. 6.13)

Key finding 2: There is a structural lack of specialized, autonomous implementing agencies.[50]

In well-functioning green industrial policy systems, the separation of strategic and operational functions between ministries and specialized agencies is a foundational design principle, one that Romania's current model does not reflect (World Bank 2025a). Line ministries set strategy, design programs, and manage political accountability; specialized agencies implement by running calls, evaluating applications on technical merit, contracting, monitoring, and making payments. This separation allows agencies to build and retain technical expertise across political cycles, hire specialized staff at competitive salaries, and operate at the pace the investment cycle requires. Poland's National Fund for Environmental Protection and Water Management (NFOŚiGW) is the regional benchmark: it manages a substantial green transition portfolio with markedly higher absorption and program quality than ministry-led implementation and maintains institutional memory across government changes. Croatia's HAMAG-BICRO and the Slovak Innovation and Energy Agency (SIEA) provide models adapted to smaller administrative systems.

Romania lacks this model, with the Ministry of Energy serving as the de facto fund manager for more than half the portfolio, creating concentration risks across all dimensions of implementation quality. The Ministry of Energy manages 60.5 percent and directly implements 55.5 percent of the total €10 billion portfolio, more than €5 billion across approximately 14 instruments, without a specialized green fund agency under its aegis. Implementation is conducted directly through ministry staff whose authority structures are described in the functional review as "rigid," whose staffing capacity scores 2.4/5 (the lowest in the assessment), and who operate under civil service rules that prevent competitive hiring of the energy, finance, and program management specialists that effective implementation requires. The concentration exposes the entire strategy to political cycles: leadership changes disrupt institutional memory, reorganizations reassign program ownership, and political priorities override technical program logic. The functional assessment explicitly notes that some instruments are influenced by political considerations requiring direct ministerial involvement, which compromises operational efficiency and neutrality.

The absence of specialized implementing bodies also directly produces industry awareness and information access failures that are limiting demand-side uptake of public support. There is no single repository or advisory institution aggregating information on energy efficiency and available support, with no open calls' registry, no instrument handbook, no repository of project success stories, and no persistent helpdesk. Advisory services, where they exist at all, are provided by only 21 percent of banks and are almost entirely tied to specific grant programs, meaning they are effectively retired when programs expire. Outside large firms in energy-intensive sectors and industry forums, awareness of energy efficiency benefits and available support remains low, and public information campaigns are largely absent. The contrast with international best practice is stark:

[50] This key finding is derived from World Bank (2025a). Please refer to Annex 1 b) for a detailed methodology.

Germany's Deutsche Energie-Agentur (DENA) provides standardized contracts, training, and sustained awareness campaigns across the economy; Ireland's Sustainable Energy Authority (SEAI) administers the Large Industry Energy Network (LIEN), facilitating structured peer learning and annual benchmarking for large organizations; and the US Industrial Assessment Centers provide free energy audits and technical advice for SMEs through a federally funded university-based program, generating a database of over 20,000 assessments available for policy analysis. Romania has no institutional equivalent to any of these.

Recommendations: *assign instruments to dedicated implementing agencies (Rec. 6.8)*

Key finding 3: Government data systems do not support the effective collection and analysis of energy efficiency data.[51]

A core constraint identified by interviewed experts was the insufficient capacity within government institutions to collect and analyze energy efficiency data, compounded by inadequate data collection frameworks and IT systems. This lack of reliable and usable data affects policymakers, firms, and financial institutions alike, as it makes it difficult to measure the effectiveness of energy-saving programs or to develop targeted energy efficiency solutions. Improving energy efficiency (EE) requires detailed, time-comparable data at both firm and industry levels. Granular data enables the identification of high-impact opportunities and targeted policy action. However, sector benchmarks are scarce, complicating peer comparisons, while publicly available data are often aggregated, fragmented, or published with significant delays. As a result, firms have limited incentives to share good practices and policymakers lack the analytical basis for targeted interventions.

In Romania, industrial energy efficiency data collection remains weak and is primarily designed to meet mandatory EU reporting requirements rather than to support policy development or firm-level improvements. Reporting is often perceived as a compliance exercise rather than a tool for analysis or feedback and publicly available data are often not detailed enough or published with significant delays. Firms submit information using basic spreadsheet templates,[52] sometimes scanned and sent as PDFs, which are not suitable for systematic aggregation or analysis.[53] Companies receive no feedback beyond confirmation of receipt. In July 2025, the Ministry of Energy introduced a new electronic platform for EE data collection. However, at the time of data collection for this study, most experts reported limited information about the platform and its expected functionality.

[51] This finding is derived from World Bank (forthcoming-e). Please refer to Annex 1 for a detailed methodology.

[52] The Excels templates comprise data on consumption by all fuels (monthly), evolution of output and share of energy in total production costs, information about energy management systems, energy recovery equipment, own renewable energy storage, energy efficiency (EE) measures implemented in the past year, EE measures planned for current year, next 2-3 years, and next 3-6 years.

[53] See https://energie.gov.ro/instructiuni-privind-raportarea-hibrida-a-eficientei-energetice-in-anul-2025/ and https://monitorizare-energie.efenclima.ro/v3/.

Recommendations: *publish sector benchmarks (Rec. 6.4); single integrated monitoring framework (Rec. 6.7); shared digital MIS (Rec. 6.9); invest in digital program management (Rec. 6.12)*

Key finding 4: Fragmented access to information and ineffective public communication on energy efficiency impacts awareness of its benefits[54]

The absence of a single repository or advisory institution aggregating information on energy efficiency (i.e. open calls, handbooks, project success stories) was identified as an issue by interviewed experts (World Bank, forthcoming-e). Experts emphasize that access to reliable, practical guidance is fragmented and often informal, whereby entrepreneurs frequently learn about opportunities through personal support networks rather than official channels. Romania lacks an electronic one-stop shop aggregating energy efficiency information and available support opportunities (i.e., public grants/ loans, tax breaks for industrial consumers, details on the white certificates program), some relevant websites are outdated, and information on policies or funding instruments is not easily accessible.

Outside large firms and industry forums, awareness remains low, and public information campaigns are largely absent. While smaller firms rely mainly on external sources, large companies typically maintain specialized teams focused on financing and energy management and thus have the resources to navigate related information, as well as to promote internal training and knowledge sharing. Exchange of information (e.g., on energy efficiency technology) occurs through consultants, energy auditors, or energy managers, as well as at conferences, events organized by industry associations or via platforms such as Energynomics in Romania. Awareness is highest in energy-intensive sectors, where competitive pressures make energy efficiency an operational priority, but low among smaller firms for whom energy costs are perceived as marginal. Knowledge gaps extend beyond relevant technologies as many smaller companies lack a basic understanding of energy procurement options, even when they offer significant cost reduction opportunities. However, growing links between energy efficiency performance and eligibility for broader support schemes (e.g. Emissions Trading System compensation, EU funds) are beginning to shift incentives.

Recommendations: *standardize application procedures and centralize information (Rec. 6.1); single national information repository (Rec. 6.10)*

Key finding 5: Administrative deficiencies are resulting in implementation delays and lack of predictability.[55]

As of December 2024, disbursement across the €10 billion portfolio stands at less than 5 percent, a figure that reflects not slow administration alone but a structural misalignment between the scale of public ambition and the institutional capacity to realize it (World Bank 2025a). Most instruments remain in selection or early contracting. The Carbon Leakage Scheme

[54] This finding is derived from World Bank (forthcoming-e).
[55] This key finding is derived from World Bank (2025a). Please refer to Annex 1 b) for a detailed methodology.

(€1.5 billion) has contracted only €124 million (8.3 percent). The National Program for Heavy Industry Support (planned at €1 billion) has not been launched. ElectricUp (€215 million) has contracted €95 million, one of the better performers. The National Recovery and Resilience Plan (NRRP), underpinning 13 instruments representing 22 percent of total portfolio funding, carries binding 2026 disbursement deadlines that are now at substantial risk of being missed, with direct financial consequences through potential claw backs of already-received EU disbursements. An estimated €4 billion EU fund commitments still has no information on open calls or identified beneficiaries.

The disbursement failure corresponds to a specific and diagnosable set of administrative problems, each of which compounds the others. Funding calls are irregular, with no multi-year calendars and no indicative future envelopes, creating stop-and-go cycles that prevent firms from incorporating public support into long-term investment planning. Application procedures are cumbersome: many firms must hire external advisors just to complete applications for EU-funded programs, and loan rejection rates in Romania stand at 22.5 percent, nearly three times the Europe and Central Asia average. Funding information is scattered across ministerial and regional websites rather than consolidated on a single platform, which is particularly acute for SMEs that lack dedicated teams to track and navigate program availability. Some 65 percent of launched programs do not disclose contracted amounts, making it impossible for firms or analysts to identify delays. Where data does exist, programs such as "New Capacities for Electricity Generation from RES" show substantial rejection rates, with fewer than half of applications reaching contracting stage, indicating that eligibility and assessment design is generating enormous waste on both sides of the process.

The banking sector's experience quantifies the predictability problem from the intermediary side: every gap in the public program pipeline translates directly into a gap in green finance availability for firms. A survey of 14 banks (covering 90.3 percent of Romanian and 18.4 percent of Polish banking assets) found that 79 percent use at least one EU funding instrument for energy efficiency lending, primarily for co-financing (71 percent), with less use for on-lending (36 percent) or innovative product development (29 percent) (World Bank, forthcoming-h). The most used funds are Cohesion Funds (64 percent), InvestEU (57 percent), the Recovery and Resilience Facility (57 percent), and the Modernization Fund (57 percent). Banks report that application procedures are complex and resource-intensive, and that uncertain start dates, cancellations, and short program cycles make it difficult to plan, allocate resources, and train staff for energy efficiency lending. When programs end, lending activity frequently declines or stops entirely, because the market depends on the next grant or co-financing round rather than having developed standalone capacity. The processing infrastructure compounds all of this: most implementing bodies rely on MS Office and email for data management, creating bottlenecks at every stage from application review through contract signature to payment verification. At the system level, Romania has no awarded projects under the EU Innovation Fund, meaning it is not drawing on one of the world's largest programs for breakthrough low-carbon technologies; and the efficiency gains available through the STEP regulation (EU 2024/795), which allows STEP-sealed projects priority access under Modernization Fund and Cohesion Policy programs without additional selection procedures, have not yet been operationalized.

The expert survey on energy efficiency also confirms that the multiplicity and complexity of regulatory requirements (i.e., reporting and compliance obligations) result in high administrative costs for firms (World Bank, forthcoming-e). While multiple EU and national programs support energy efficiency-related investments, the fragmentation of information across institutions and platforms makes it difficult for potential beneficiaries to identify and access relevant financial support. Experts report that fundings calls are irregular and applications are cumbersome with often complex eligibility criteria, leading to high rejection rates. Funding information tends to be scattered across ministerial and regional websites, especially problematic for SMEs who lack sufficient resources to navigate.

Recommendations: *standardize application procedures (Rec. 6.1); EU Innovation Fund strategy (Rec. 6.2); annual operational audits (Rec. 6.5); implementation audit (Rec. 6.6); publish multi-year funding calendar (Rec. 6.11)*

Table 5 Key short-term recommendations - Governance

Area	Short-term actions	Key Finding(s)
Design	**6.1 Standardize and simplify application procedures**, publish plain-language "instrument sheets" summarizing eligibility criteria and scoring, and centralize program information on a single public platform accessible to SMEs.	Key Finding (KF) 4, 5
	6.2 Develop a strategy for accessing the EU Innovation Fund and operationalizing STEP seal priority access under Modernization Fund and Cohesion Policy programs, closing the gap between European and national green financing.	KF 5
Implementation	**6.3 Urgently resource ANRE's enforcement capacity**: revise energy audit legislation to make compliance verifiable, introduce meaningful penalties for non-compliance, and develop a roadmap toward a central Energy Efficiency Obligation scheme.	KF 1
	6.4 Require all instruments to publish sector benchmarks and make open-access data on allocations, beneficiaries, and verified outcomes a standard condition of program operation.	KF 3
	6.5 Introduce annual operational audits with public reporting on absorption rates, output delivery, and outcome indicators, creating an accountability framework that rewards performance rather than procedural compliance.	KF 5
	6.6 Conduct an implementation audit across the portfolio to identify the specific bottleneck at each instrument (legal, administrative, or capacity-related) and assign responsible owners and resolution timelines.	KF 5

	6.7 Develop a single integrated monitoring framework covering all public financing instruments, tracking spending, outputs, and outcomes, with results published on public dashboards.	KF 3
	6.8 Assign specific green transition instruments to dedicated implementing agencies, either repurposed from existing bodies (the SME Agency, the Innovation Agency) or newly created, with clearly defined mandates, protected multi-year operational budgets, and insulation from short-term political interference, specialized technical staff and multi-stakeholder governance boards.	KF 2
Data infrastructure	**6.9 Build a shared digital Management Information System (MIS**) to replace MS ad hoc spreadsheets and email-based workflows and to be used by both EU-funded and nationally funded programs. Minimum data standards, interoperability with financial and audit systems, and designated data stewards in each implementing body would reduce administrative burden and enable real-time monitoring of progress and results.	KF 3
	6.10 Establish and permanently fund a single national information repository (one-stop-shop) and advisory service for green transition support, aggregating open calls, eligibility criteria, instrument handbooks, project success stories, and sector benchmarks, modeled on Germany's DENA or Ireland's Sustainable Energy Authority (SEAI) and accessible through existing regional delivery points such as Regional Development Agencies or active and nascent market programs, such as energy audits or EMS promotion drives. .	KF 4
	6.11 Publish a multi-year green transition funding calendar for all public financing instruments, specifying indicative call opening dates, budgets, and focus areas; this single action would materially transform the investment planning environment for both firms and banks.	KF 5
	6.12 Invest urgently in digital program management infrastructure to replace MS Office and email, enabling real-time tracking across the full program cycle.	KF 3
Coordination	**6.13 Upgrade the CISC mandate to include authority to resolve conflicts between line ministries**, formally align climate-action instruments with competitiveness instruments at the design stage of each new call, and report on cross-portfolio coherence to a political-level accountability body on a regular schedule.	KF 1

Note: ANRE = Romanian Energy Regulatory Authority; CISC = Inter-Ministerial Committee on Climate Change; DENA = German Energy Agency; SMEs = small and medium-sized enterprises; STEP = Strategic Technologies for Europe Platform.
Source: World Bank.

7. Public-private dialogue

Effective public-private dialogue mechanisms are necessary to ensure that the proposed recommendations can become smart industrial policy reform packages. Coordination mechanisms are particularly critical when an industrial strategy, such as the Romania Green Industrial Plan, deals with several different industries and aims to provide complementary input needed to achieve the objectives. The dialogue process ensures that policy reforms and investments are compatible, not duplicative, and both necessary and sufficient. A public process also ensures that common expectations about policy objectives and reforms are set for all relevant stakeholders, including the public. Such information exchange can extend to international forums and enhance the empirical underpinnings of selected interventions by improving exposure to and learning from best practices. The process can also safeguard against rent seeking and policy capture, while at the same time motivating and sustaining firm participation.

It is critical to invite the relevant stakeholders to any consultative process. Those should at minimum include policymakers that are critical to the identified reform areas and public investments, industry representatives from both established and nascent industries, and technical experts. The Productive Capabilities Data Lab is an AI value chain mapping tool that can facilitate the identification of private sector firms that are relevant to the identified policy actions and reform areas in the sectors of focus. The tool can map companies to their position in the value chain by using data from business registries, which often classify companies according to their main activities using taxonomies, such as NACE or International Standard Industrial Classification (ISIC). By mapping the products in the value chain to these taxonomies, the tool can link companies to a version of the value chain aggregated at the level of detail permitted by the taxonomy.

The effectiveness of public-private dialogue mechanisms can be enhanced with a set of best practices that can help policymakers avoid some of the pitfalls of past industrial policy efforts. Those include, but are not limited to, inclusive representation of relevant industries and public authorities, supported by dedicated technical staff; limited size of the representative group to build trust among participants; a long-term orientation that also includes quick wins to build credibility; embedded plan for potential failure of some policy efforts and flexible processes for strategy reorientation; and rigorous ex-ante systematic evaluations and cost-benefit analysis to inform supported interventions. These and similar principles should be considered when organizing consultative processes that can play a key role in the effective design of smart green industrial policy packages, aimed at supporting Romanian firms and informed by the analyses conducted under the GRIN RAS and concurrent World Bank analytical tasks.

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Annex 1: Methodologies

a) Decomposition analysis

The analysis draws on a firm-level panel dataset for Romania covering 2010-2022, linking financial and performance data from the Structural Business Survey (SBS) and the Ministry of Finance (MoF) with energy consumption data from the Energy Survey (ES), all provided by the National Institute of Statistics (INS) via the General Secretariat of the Government of Romania, matched at the firm level. Since the Energy Survey focuses on larger, energy-intensive companies, a sample expansion is applied: energy consumption is estimated for firms not covered by the ES by dividing their reported energy costs by median sector-level energy prices, increasing firm coverage approximately fourfold. Financial variables are deflated using producer price indices at the four-digit sector level from the national Institute of Statistics (INS) for Romania and Statistics Poland (Główny Urząd Statystyczny, GUS) for Poland, and outliers in energy efficiency are removed. Energy efficiency is defined as deflated sales per Terajoule (TJ) of energy consumed. CO_2 emissions are estimated by applying fuel-specific carbon content factors from the Intergovernmental Panel on Climate Change (IPCC) 2006 (IPCC 2006) Guidelines to energy quantities normalized into TJ. The analysis covers manufacturing, construction, commerce, and services, excluding energy-related sectors (mining, electricity and gas supply, water and waste management, and coke and petroleum products), Agriculture (A), Financial Services (K), Public Administration and Defense (O), and Social Work (88).

Changes in aggregate energy consumption and CO_2 emissions are decomposed into four components: a scale effect driven by output growth; a structural transformation effect reflecting shifts in the sectoral composition of the economy; a market reallocation effect capturing whether resources flow toward more or less efficient firms within sectors; and a sector intensity effect measuring changes in the average energy intensity of firms within each sector due to technology adoption or improved management. These four components sum to the total observed change and are computed at the aggregate level and disaggregated by firm size, age, ownership, and trade status.

Firm-level correlates of energy efficiency are estimated through an ordinary least squares (OLS) regression comparing firms within the same sector, region, and year, controlling for size, age, capital intensity, productivity, ownership, and trade status. A separate specification with firm fixed effects estimates the within-firm returns to investment in machinery and equipment on energy efficiency with a three-year lag. Finally, a simulation exercise estimates the aggregate energy and emissions savings from raising all firms below their sector's median efficiency to that level, holding output constant, and computes associated firm-level profit gains.

b) Policy mix

This methodology is grounded in the World Bank's Policy Effectiveness Review (PER) framework, initially piloted in 2014 and subsequently updated to incorporate instruments supporting the green transformation of the private sector (World Bank 2014). The approach is designed to assess the effectiveness and coherence of a national portfolio of policy instruments aimed at advancing industry decarbonization, climate adaptation, and green competitiveness.

The framework is organized around three interconnected: industry decarbonization, which focuses on reducing greenhouse gas (GHG) emissions; private sector climate adaptation, which targets firm resilience to physical climate risks; and green competitiveness, which supports capturing opportunities in emerging green markets. These three pillars provide the thematic structure against which the policy portfolio is mapped, assessed, and evaluated.

The review is conducted through four sequential analytical steps. The first is portfolio mapping, a comprehensive stocktaking of the strategic and institutional framework underpinning public support to the private sector. This involves cataloguing all relevant policy instruments, their funding sources, delivery mechanisms, targeted industries, and budget allocations across a standardized set of variables. The mapping covers both national and EU-funded programs. The second step is a country context diagnostic, an evidence-based assessment of Romania's private sector green outcomes, identifying the top CO_2-emitting sectors, the state of climate vulnerability among firms, and the structural barriers to green investment. This diagnostic establishes the demand side against which the supply of policy instruments is assessed. The third step is an alignment assessment, a high-level gap analysis comparing the relative allocation of funds across the portfolio with the country's identified needs and green transition priorities, highlighting areas of over- or under-investment relative to the scale of the challenge. The fourth step is a functional analysis, a deep-dive evaluation of a selected subset of key instruments, scored on a scale of 1 to 5 across 31 indicators organized around three dimensions: design, implementation, and governance.

The functional analysis evaluates each instrument along these three dimensions. Design examines whether the instrument has clearly defined objectives, a robust Theory of Change (ToC), and an evidence-based justification for public intervention. Implementation assesses the efficiency of application and selection processes, the adequacy of budget and staffing resources, the quality of monitoring and evaluation systems, and the use of learning evidence to improve delivery. Governance reviews inter-institutional coordination mechanisms, program-level governance arrangements, and the instrument's capacity to navigate regulatory constraints.

The methodology focuses exclusively on instruments that target firms and research organizations. Instruments directed solely at the energy sector, individual citizens, public authorities, or agricultural holdings are excluded from the analysis. Primary data sources include program planning documents, periodic reports from managing authorities, state aid schemes

approved by national regulatory bodies, and structured consultations with program administrators and stakeholders.

c) Sector assessments

The sector assessment follow a structured four-phase methodology grounded in five-forces competition modeling, the diamond model of national competitiveness advantage, value chain strategic analysis tools, and a triple bottom line framework to assess three green industrial value chains in Romania.

The three value chains were shortlisted through a desk review mapping each sector's ecosystem and an estimate of future value generation potential derived through expert consultations. Sectors were scored against three categories of criteria: desirability (economic, environmental, and social benefits), feasibility (technical, financial, and political viability, as well as demonstrated global demand and local supply capacity), and additionality (the degree to which the analysis would generate compelling new insights or catalytic impact beyond existing assessments). The specific sectors are intended as examples, and the analytical approach is intended to be replicable, so similar assessments could be conducted on a broader range of sectors in the economy.

The first phase builds a comprehensive picture of each chain's local context through desk research, regulatory review, and field interviews. The desk research maps the full value chain, identifying key actors, the physical flow of goods, the activities performed at each stage, and the information flows connecting stakeholders. This is complemented with a review of the public policy framework and deepened with 20-30 key informant interviews per value chain. The findings are summarized in a profile of each value chain's economic, social, and environmental characteristics.

The second phase situates each value chain within its global market context, establishing the scale, timing, and competitive intensity of potential entry. For each value chain, the team benchmarks global demand trajectories, installed and planned capacity, cost and pricing dynamics, and geographic concentration of production. The analysis identifies strategic segments, market opportunities that present a viable fit between external demand and domestic capability, and entry points that are pragmatic and allow firms to learn, accumulate capabilities, and upgrade.

The third phase assesses identified segments and market opportunities against Romania's existing capabilities and structural entry requirements to identify the binding constraints and market or policy failures that most directly limit feasibility. Romania's capabilities are evaluated against these requirements using trade data, revealed comparative advantage, existing industrial

assets, and firm-level interviews. The diagnostic identified market failures and policy gaps that are preventing Romania from capturing the identified opportunities.

The final phase translates these findings into actionable policy recommendations, benchmarked against international best practices and validated with key public stakeholders, serving as a robust base for informed and informative dialogue with the private sector. Additional validation workshops with policymakers, industry representatives, and experts can be organized to pressure-test, refine, and prioritize the recommendations that will serve as inputs to Romania's Green Industrial Plan.

d) Firm adoption of technology survey

The Firm-level Adoption of Technology (FAT) survey, conducted in Romania in 2025, covers 1,516 firms with five or more employees in the manufacturing and service sectors. selected from a nationally representative sample stratified by firm size, geographic area, and sector. Fieldwork was carried out face-to-face with business owners or top managers with an average response rate of 44 percent.

The FAT survey measures technology adoption at the level of individual business functions rather than the firm as a whole. It covers over 300 digital and green technologies across more than 50 business functions.

Firms' level of digitalization is measured across seven standard tasks all firms perform (administration, production planning, sourcing and procurement, marketing and consumer information, sales, payment methods and quality control). For each of these, technologies are classified along a ladder of up to five levels of sophistication, ranging from basic tools (e.g., handwritten processes) to advanced systems (e.g., enterprise resource planning (ERP). Two indices are constructed on a 1–5 scale (from basic to advanced): an adoption index (whether a technology is present in the firm) and an intensive use index (which technology is most frequently used for a given function).

A dedicated green module captures energy-saving equipment, smart energy management, renewable energy production, and green management practices. Green technologies are tools or systems designed to reduce environmental impact and improve resource efficiency, such as LED lighting and programmable thermostats. Green management practices are organizational strategies that enhance environmental performance, including adopting the ISO 14001 environmental management standards and monitoring CO_2 emissions. Two indices of green adoption were constructed by counting respectively, for each firm, the number of green technologies implemented, and the number of green management practices adopted.

Additionally, the FAT survey captures the firms' production of renewable energy, used as a third indicator of green adoption.

These data were used to document Romanian firms' patterns of technology adoption and use, benchmarked against 18 countries where the FAT survey has been implemented. By combining information on technology use with firms' characteristics, balance sheets, employment, and energy consumption, the survey provides a nuanced understanding of the drivers and barriers to moving up the technology ladder, as well as how technology use links to firm performance across energy efficiency, productivity, and employment gains.

e) Firm resilience to climate shocks

This methodology follows a microeconomic and corporate finance approach to assess how exogenous climate shocks transmit through firm-level balance sheets. The analysis focuses on floods as the predominant climate-related risk for Romanian businesses, examining how asset damage and revenue disruptions affect firms' financial health and what public support would be required to sustain viable firms through such events.

The analytical framework conceptualizes climate risk as a function of three components: hazard (the nature, location, and frequency of the climate event), exposure (the assets and economic activity located in risk zones), and vulnerability (the degree of damage and financial impairment experienced by affected firms). Three flood return periods are simulated, 1-in-10, 1-in-20, and 1-in-100 years, using high-resolution probabilistic flood maps from the Joint Research Centre's Copernicus Emergency Management Service (GLOFAS). Exposure is determined through satellite-derived data on non-residential built-up areas from the Global Human Settlement Layer (GHSL), and financial impacts are estimated using balance sheet and income statement data for approximately 800,000 Romanian firms from the National Trade Register Office (ONRC).

The core of the analysis consists of four analytical steps. First, flood scenarios are simulated by translating flood depth into damage ratios through a piece-wise linear function, estimating asset losses as a share of physical capital destroyed and revenue losses based on the number of days of operational interruption. Second, firm responses are modelled using sector-specific elasticity estimates derived from historical data (2011–2023), capturing how operating costs, current assets, and current liabilities adjust proportionally to revenue shocks. Third, financial vulnerability is assessed across four dimensions: profitability, measured by shifts in operating margins and net earnings; liquidity, captured by the Cash Burn Rate (CBR), which indicates how long a firm's cash reserves would last under the shock; solvency, expressed as Debt at Risk (DaR), covering the

outstanding debt of firms breaching thresholds for interest coverage, current ratio, and leverage; and employment, expressed as Employment at Risk (EaR) for firms failing the same vulnerability thresholds. Fourth, the funding needs and fiscal costs of potential public interventions are estimated, including direct lump-sum payments, tax deferrals, and credit guarantees, with the latter valued using present value, Black-Scholes, and jump diffusion methods.

The methodology acknowledges several limitations. The shock scenarios are deterministic and focus only on direct revenue and asset losses, excluding secondary effects such as supply chain disruptions or input price increases. Due to the absence of precise firm-level address data, flood damage is spatially aggregated at the county level. The exercise is also static and does not account for general equilibrium effects such as changes in household spending or broader macroeconomic feedback.

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