



CENTER FOR
THE STUDY OF
DEMOCRACY

A photograph of an industrial facility at night, illuminated by warm yellow lights. The scene features several tall, cylindrical structures, possibly cooling towers or chimneys, and a complex network of pipes and walkways. The background shows a dark sky with some distant lights.

Energy and Climate Security in Europe

From Crisis Response to
Structural Transformation

Energy and Climate Security in Europe

**From Crisis Response to
Structural Transformation**



The Russian invasion of Ukraine marked a turning point in Europe's energy and climate security, exposing deep structural vulnerabilities in the EU's energy systems. While the current crisis began prior to the war, Russia weaponized its energy exports to undermine the EU's common foreign and energy policy stance, testing the bloc's resilience and unity. This report introduces the updated Energy and Climate Security Risk Index (ECSRI), which is a comprehensive, data-driven tool designed to assess systemic risks across all EU member states.

The Index evaluates energy security through four interconnected dimensions: geopolitical risk, affordability, reliability, and sustainability. It reveals a growing divide between transition leaders and vulnerable laggards, underlining the need for differentiated yet coordinated policy responses across the Union.

Beyond Russian fossil fuel dependency, the report identifies new forms of strategic exposure, including Europe's rising dependence on third-country supply chains for critical raw materials and renewable energy technologies. It calls for an integrated policy shift: one that treats the energy transition not only as a climate imperative, but as a cornerstone of Europe's economic sovereignty and strategic autonomy.

Authors:

Martin Vladimirov, Director, Energy, Climate, and Geoeconomics, Center for the Study of Democracy

Marius Köppen, Analyst, Energy and Climate Program, Center for the Study of Democracy

Molly Rickles, Analyst, Energy and Climate Program, Center for the Study of Democracy

Editorial Board:

Dr. Ognian Shentov

Ruslan Stefanov

Dr. Todor Galev

Check out the Online
Index Platform below



This work is licensed under the [Creative Commons Attribution NonCommercial-NoDerivatives 4.0 International License](https://creativecommons.org/licenses/by-nc-nd/4.0/).

Cover photo: Pixabay

ISBN: 978-954-477-536-0

Sofia: Center for the Study of Democracy, 2025.

CONTENTS

ENERGY AT THE CORE OF THE EU ECONOMIC SECURITY STRATEGY	15
MEASURING ENERGY AND CLIMATE SECURITY RISKS IN EUROPE.....	19
THE GREAT DIVIDE	23
Geopolitical Risks	26
Affordability Risks	35
Reliability Risks.....	44
Sustainability Risks.....	53
WHAT'S NEXT	65
ANNEX 1 REGIONAL AND COUNTRY PROFILES	69
Northwestern Europe.....	69
Southern Europe	76
Scandinavia and the Baltics.....	83
Central and Eastern Europe.....	90
ANNEX 2 ECSRI RANKING	97

LIST OF FIGURES

Figure 1. Energy and Climate Security Risks across the EU	9
Figure 2. Dimensions of the Energy and Climate Security Risk Index	19
Figure 3. Energy and Climate Security Risk Score across the EU	23
Figure 4. Geopolitical, Affordability, Reliability, and Sustainability Risk Pillars	25
Figure 5. Geopolitical Risks in the EU	27
Figure 6. Evolution of Geopolitical Risk Indicators in the EU	29
Figure 7. EU Natural Gas Imports by Country of Origin	29
Figure 8. EU Import Dependence on Critical Raw Materials and on China.	32
Figure 9. Affordability Risks in the EU	35
Figure 10. Risk Index for Average EU Retail Electricity and Gas Prices . . .	36
Figure 11. Value of EU Natural Gas Imports in Million EUR	37
Figure 12. EU Inflation vs. Energy Expenditures per GDP	38
Figure 13. Emission Intensity of the Economy and Affordability Risk (2023)	40
Figure 14. Affordability Risks Across EU Member States with Carbon-Intensive Economies	41
Figure 15. Energy Expenditures Intensity and CO ₂ Costs	43
Figure 16. Reliability Risks in the EU	44
Figure 17. Reliability Risk Indicators	45
Figure 18. Gas Infrastructure Reliability Does Not Always Mean Security of Supply	49
Figure 19. Sustainability Risks in the EU	54
Figure 20. EU Real GDP and GHG Emissions Have Decoupled Over Time	55
Figure 21. A Higher Share of Renewables Has Lowered Emissions in Recent Years.	56
Figure 22. Less Energy-intensive Countries Had Lower Energy Expenditures per GDP in 2023	57
Figure 23. The Security of Supply of Raw Materials and Renewable Energy Equipment and Material Consumption	60

LIST OF BOXES AND TABLES

Box 1. The Methodology	21
Box 2. Russian Gas Enablers in Europe	30
Box 3. Mitigating the Impact of Rising Carbon Costs	40
Box 4. The Kremlin Playbook for Undermining the Reliability of Supply.....	48
Box 5. The Iberian Peninsula Blackout: A Warning for High-Renewables Grids.....	50
Box 6. The Sustainability Conundrum: The Case of Finland	61
Table 1. Ranked Risk Values for 2023	97

LIST OF ABBREVIATIONS

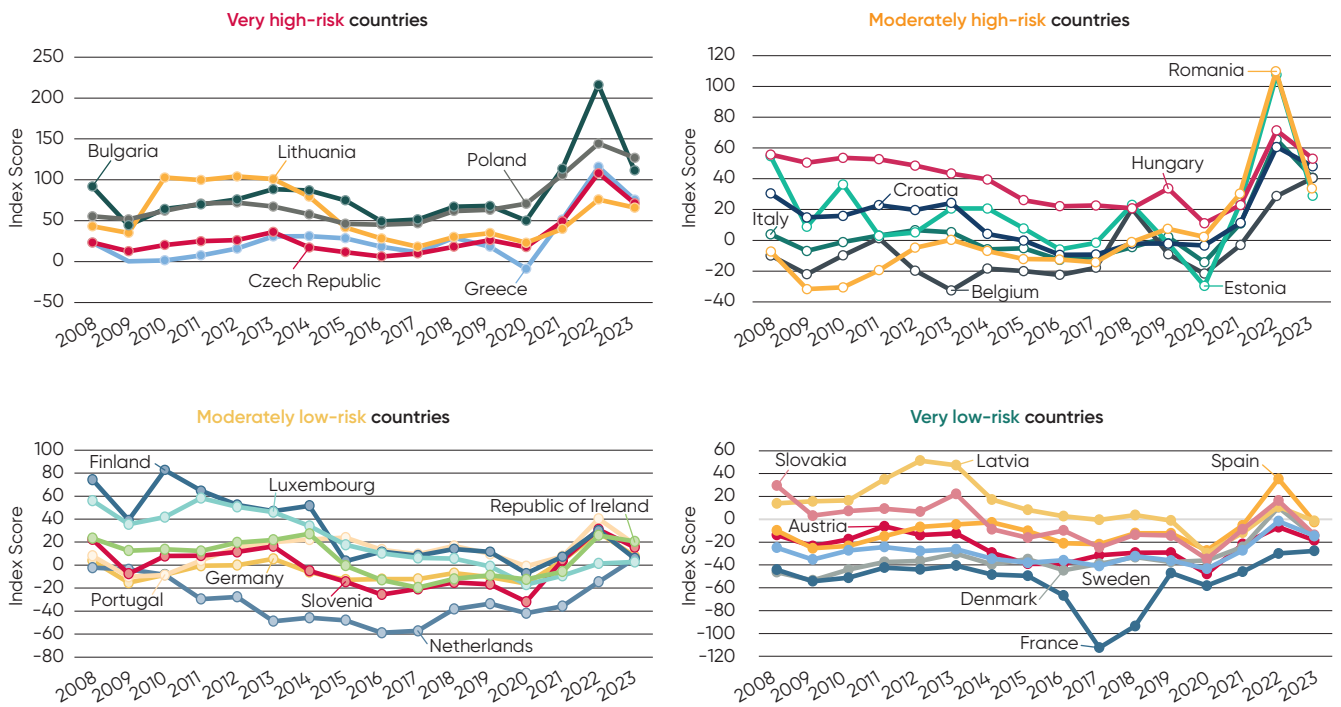
BCM	Billion Cubic Meters
CBAM	Carbon Border Adjustment Mechanism
CO₂	Carbon Dioxide
CfD	Contracts for Difference
CCfD	Carbon Contracts for Difference
CRM	Critical Raw Materials
ESG	Environmental, Social, and Governance
ECSRI	Energy & Climate Security Risk Index
ETS	Emissions Trading System
EU	European Union
EV	Electric Vehicle
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GW	Gigawatt
HVDC	High Voltage Direct Current
LNG	Liquefied Natural Gas
PPA	Power Purchasing Agreement
PV	Photovoltaic
RES	Renewable Energy Sources
TCO₂	Tonne of Carbon Dioxide
VAT	Value-Added Tax

EXECUTIVE SUMMARY

Europe is in the midst of a shift in its energy and climate policy. This shift will determine not only the continent’s success in meeting its decarbonization goals, but also EU’s position in the global economy and the resilience of its members’ democratic systems. The **multiple crises** hitting the European energy sector in the past three years have brought this challenge into sharp focus. Russia’s **weaponization of fossil fuel exports**, volatile global oil and gas markets, and the mounting **competition for the raw materials and clean technologies** that underpin the green transition have exposed deep vulnerabilities in the EU’s energy system.

The immediate response to the Ukraine war shock by diversifying gas imports away from Russia, accelerating renewable energy deployment, and cushioning households and businesses from extreme price spikes demonstrated the **EU’s capacity to act under pressure**. But these actions were largely reactive. The next phase must be strategic, moving from crisis management to system redesign. That means building an energy system capable of delivering clean, affordable, and reliable energy at scale, while strengthening Europe’s competitiveness, geoeconomics and strategic autonomy.

Figure 1. Energy and Climate Security Risks across the EU



Source: CSD based on ECSRI data.

The **Energy and Climate Security Risk Index (ECSRI)**, developed by the Center for the Study of Democracy, provides a comparative, data-driven assessment of these challenges across all EU member states. By ranking vulnerabilities in four interconnected risk categories – **Geopolitics, Affordability, Reliability, and Sustainability** – the Index offers a lens through which to understand the distribution and interaction of risks. Its results reveal both a widening gap between transition leaders and laggards, and the fact that these risks tend to cluster, with high emissions intensity often correlating with poor affordability, lower system reliability, and geopolitical exposure.

Geopolitical Risks

Geopolitical risks in Europe's energy landscape have changed in character but not in significance. While the EU has drastically reduced its imports of Russian fossil fuels, **the job of achieving full strategic independence is incomplete**. Several member states, particularly in Central and Southeastern Europe, remain bound by long-term supply contracts, infrastructure configurations, or nuclear fuel dependencies that constrain their room for maneuver. In these cases, the inertia of past decisions continues to shape present vulnerabilities, limiting diversification options and leaving national energy systems exposed to geopolitical leverage.

The challenge is compounded by the **emergence of new dependencies in the clean energy sector**. The rapid buildout of renewable capacity has been accompanied by an increasing reliance on imports of solar panels, wind turbine components, and battery technologies, much of which originate in China. Similarly, supply chains for critical raw materials (from lithium and cobalt to rare earths) are concentrated in a small number of producing and processing countries, often outside Europe's strategic alliances. The new vulnerabilities map unevenly across the EU, with some member states showing **significant exposure to supply chain shocks in clean tech** just as they begin to decouple from Russian fuels.

Addressing these evolving geopolitical risks requires a **layered approach**: accelerating domestic and allied-country production of key energy technologies, integrating critical raw material strategies into climate and industrial policy, and ensuring that diversification extends beyond fuel imports to encompass the entire value chain of the clean economy.

Affordability Risks

Affordability risks have emerged as the most politically sensitive and economically consequential in the European energy security profile. The price shocks of 2022–2023 revealed how quickly high energy costs can **erode public trust and industrial competitiveness**. Although wholesale prices have since fallen, retail energy costs remain elevated in many parts of the EU, particularly in Central, Eastern, and Southern Europe. This is not merely a short-term after-effect of the crisis but a structural challenge tied to system design, carbon pricing, and the pace of investment in clean infrastructure.

The **high emissions intensity** is a strong predictor of affordability risks. Economies with coal-heavy power systems and low renewable penetration, such as Poland, Bulgaria, and Czechia, face a **double burden**: they incur higher costs from the EU Emissions Trading Scheme while remaining more vulnerable to fossil fuel price volatility. In these countries, the combination of legacy infrastructure, inefficient housing stock, and slow industrial electrification amplifies the risk of households and small businesses being priced out of energy access, while energy-intensive industries face competitiveness pressures that could prompt relocation to markets with lower energy costs.

A durable affordability strategy must **go beyond short-term subsidies**. It should combine market reforms that secure low-cost clean power for industry through long-term contracts, targeted investment in energy efficiency to reduce demand, and tailored support for vulnerable households. Without such measures, Europe risks entrenching regional inequalities and undermining the political coalition necessary to sustain the transition.

Reliability Risks

The nature of reliability risks in Europe's energy systems has shifted fundamentally. In the era of fossil fuels, reliability was largely a question of securing adequate fuel supply and generation capacity. Today, with the rapid rise of variable renewable energy in the generation mix, the challenge is increasingly about **system integration and stability**. Even countries with significant renewable capacity face high reliability risks if transmission, distribution, and storage infrastructure lag behind generation growth.

The blackout that struck the Iberian Peninsula in April 2025 was a stark warning. Triggered by the sudden loss of 15 GW of solar generation, it exposed the vulnerabilities of systems where inverter-based generation dominates but grid-forming technologies and balancing capacity remain insufficient. Similar integration challenges are now evident in Italy, Germany, and several Eastern European member states. In such context, reliability is less about whether the lights stay on today and more about whether the system can withstand the stress of rapid renewable scaling tomorrow.

Meeting this challenge demands **anticipatory investment in both physical and digital infrastructure**. Transmission and distribution networks must be expanded and upgraded to accommodate new generation hubs. Cross-border interconnections should be reinforced to allow power to flow to where it is needed most. Grid digitalization, flexible demand management, and storage solutions must be deployed at scale to maintain stability as renewable penetration increases. Without this backbone, Europe's clean energy ambitions risk being undermined by the very variability they are designed to harness.

Sustainability Risks

Sustainability risks capture the **gap between Europe's decarbonization targets and the actual pace of transformation** in energy production,

consumption, and industrial processes. European countries with high emissions intensity tend to perform poorly across multiple risk dimensions, making sustainability both a standalone challenge and a driver of other vulnerabilities.

Poland, Bulgaria, and Czechia remain among the most carbon-intensive economies in the EU, with slow progress in coal phaseouts, lagging investment in heat electrification, and insufficient building renovation rates. These structural inefficiencies translate into higher affordability risks, greater exposure to carbon pricing, and a heavier reliance on imported fossil fuels. In contrast, Nordic countries such as Sweden, Finland, and Denmark illustrate the benefits of a coherent, integrated approach in which renewable deployment, industrial decarbonization, and high governance capacity reinforce one another.

Closing the sustainability gap requires accelerating fossil fuel phaseouts in tandem with building out clean replacement capacity, ensuring just transition measures for affected workers and regions, and strengthening governance to unblock permitting bottlenecks. Industrial decarbonization must be scaled through electrification, hydrogen deployment, and carbon capture where viable, while material efficiency and circularity should become central to energy and climate policy. Sustainability is not merely an environmental imperative; it is the precondition for lasting affordability, reliability, and geopolitical resilience.

The Way Forward

Europe's energy transition is the **geo-economics compass** by which its future prosperity, resilience, and sovereignty will be set. Vulnerabilities in one category, whether geopolitical, affordability, reliability, or sustainability, rarely exist in isolation. Left unaddressed, they reinforce one another, magnifying the overall risk profile of the EU and its member states.

To succeed, Europe's energy and climate security strategy must treat energy as the foundation of a competitive, autonomous, and democratic Europe. That means integrating industrial policy, social protection, and strategic diversification into a single framework that can withstand both market volatility and geopolitical shocks.

To solve this energy policy conundrum the EU should:

- 1. Embed strategic autonomy into energy policy** by diversifying fossil fuel and clean technology supply chains, scaling domestic and allied-country production of renewables and storage technologies, and integrating critical raw material strategies into climate and industrial planning.
- 2. Make energy affordability central to competitiveness** through long-term clean power contracts for industry, targeted carbon contracts for difference, and energy efficiency programs for households, replacing blanket fossil fuel subsidies with targeted support.

3. **Rebuild Europe's energy backbone for reliability** with accelerated investment in transmission, distribution, and interconnections, along with large-scale deployment of storage, digital grid management, and demand-side flexibility to integrate high shares of renewable generation.
4. **Close the sustainability gap** by sequencing fossil fuel phaseouts with clean capacity buildout, accelerating industrial electrification, and embedding just transition measures to ensure social and political support across all regions.
5. **Strengthen governance and delivery capacity** at national and regional levels by targeting EU funding and technical assistance towards regulatory reform, permitting acceleration, and institutional performance improvements that unblock the implementation of national energy and climate plans.
6. **Accelerate innovation in cutting-edge low-carbon technologies** by aligning EU research and innovation funding with deployment incentives for hydrogen, advanced storage systems, carbon capture and utilization, small modular reactors, and next-generation renewable technologies. Innovation must be embedded in industrial strategy so that Europe not only adopts but also develops and exports the technologies needed for deep decarbonization.

If the EU acts decisively on these fronts, it can lead the global clean energy economy on its own terms, turning the vulnerabilities exposed in recent years into the foundations of **a more resilient, competitive, and strategically autonomous Europe**. If it does not, the transition risks becoming fragmented, costly, and politically brittle, leaving the continent exposed to a new generation of energy and climate security risks that can make Europe geoeconomically irrelevant.

ENERGY AT THE CORE OF THE EU ECONOMIC SECURITY STRATEGY

In the early 2020s, Europe confronted a painful truth: its economy was far more vulnerable than its policymakers had long assumed. **Energy**, the silent enabler of growth, competitiveness, and modern life, had become **the continent's biggest strategic liability**. The rupture came not just from Russia's brutal invasion of Ukraine, though that was the most visible trigger. It came from a deeper miscalculation: the belief that market liberalization and globalization had made energy security a second-order issue. In reality, Europe had built its prosperity atop imported fossil fuels, often from authoritarian states, and its clean energy ambitions on technologies and materials dominated by geopolitical competitors. The result was a system that looked stable in spreadsheets but cracked under pressure.

How does Europe **regain its economic sovereignty** in an era of energy scarcity, great power competition, and accelerating decarbonization? The answer requires more than replacing Russian gas. It requires reimagining energy security not as a siloed policy goal, but as a foundation of the EU's new geoeconomic compass.

The energy crisis in Europe starkly demonstrated that the EU had made little progress in strengthening its energy security even in the face of the direct threat to its economic sovereignty following the Russian invasion of Ukraine. European leaders responded with urgency. Over €1 trillion in subsidies flowed to shield households and industries. But the cost of inaction before the crisis was staggering: dozens of energy-intensive factories shuttered,¹ millions of jobs lost or relocated,² and a continent forced to admit that its dependency was not only economic but existential.

This reckoning catalysed action. The EU's REPowerEU strategy ignited record investments in solar, wind, and energy efficiency. Permitting was streamlined. Heat pumps and building renovations accelerated. In just two years, the EU added over 120 GW of solar and 30 GW of wind. Energy demand dropped by up to 20%. Greenhouse gas emissions fell 8% in 2023.³ These are not small wins. They are signals of a new model that decouples prosperity from fossil fuels and restores agency to Europe's economies.⁴

Yet, Europe is not out of the woods. Although it is largely Russia's targeted cuts in the supply of natural gas that brought about the surge in natural gas and electricity prices, EU countries have so far failed to complete their decoupling from Russian energy imports. Yes, the share of Russian gas in the EU's import mix has fallen from around 40% before the war to just around 10% after the halt of the Ukrainian gas transit. However, purchases of Russian

¹ Crellin, F., Buli, N. and Chestney, N. "Gas price shock set to add to Europe's industrial pain", *Reuters*, 6 December 2024.

² Ibid.

³ European Commission, [REPowerEU Plan](#), 18 May 2022.

⁴ European Commission, [Renewable Energy Achievements Update](#), 2024.

LNG and pipeline gas rose by more than 25% in 2024 as the two largest Russian gas exporters, Gazprom and Novatek, dumped cheaper gas on the European market undercutting the competition from alternative, mostly US LNG, supply.⁵

Europe is paying around five times higher prices for its gas consumption than the U.S. and roughly 70% more than China.⁶ As natural gas is clearing the electricity market in the merit order of power plants entering the system, electricity prices have also shot up to levels at least two times higher than the 10-year average before the Russian invasion.

As of 2023, 60% of European firms cited high energy prices as a top investment constraint – 20 percentage points above the U.S.⁷ Complex permitting, fragmented regulation, and weak coordination are slowing the clean energy rollout. And despite vast subsidies, Europe continues to bleed manufacturing capacity to lower-cost competitors.

The rapid energy transformation after 2022 could become the foundation for renewed industrial competitiveness. Clean technologies such as floating offshore wind, advanced battery storage, and green hydrogen, once viewed as costly, are gaining market traction. The European Commission has positioned these sectors as strategic growth pillars under the Competitiveness Agenda for 2024–2029,⁸ and former European Central Bank President Mario Draghi's 2024 report underscores the centrality of energy resilience in Europe's economic revival.⁹ Energy policy has become industrial policy.

As dependency on Russian gas receded, another asymmetry emerged: the EU's vast reliance on Chinese-dominated supply chains for clean technologies and critical raw materials. Lithium, cobalt, nickel, rare earths are the building blocks of Europe's industrial future. And in too many cases, their price, availability, and processing are determined not in Brussels or Berlin, but in Beijing. China, for example, dominates the processing of lithium, cobalt, nickel, and rare earth elements, often controlling 35–70% of global refining.

This is where the conversation must shift – from crisis response to structural reform. Energy policy is no longer about balancing supply and demand. It is about **geoeconomic positioning**: Where are your vulnerabilities? Who controls your inputs? How do your energy choices affect your capacity to grow, compete, and govern?

That's the role of **energy security** now: it's the connective tissue between **industrial policy, climate ambition, and democratic resilience**. The EU has made important progress on this front. In 2024, the European Commission launched a comprehensive economic security strategy, introducing new tools for foreign investment screening, dual-use R&D protections, and

⁵ European Commission, [EU Energy Outlook Press Release](#), 2023.

⁶ International Energy Agency, [European gas market volatility puts continued pressure on competitiveness and cost of living](#), 23 February 2025.

⁷ European Commission, [The future of European competitiveness: In-depth analysis and recommendations](#), 2024.

⁸ European Commission, [Competitiveness Agenda 2024-2029](#), 2024.

⁹ European Commission, [Mario Draghi Report on EU Competitiveness](#), 2024.

critical raw materials sourcing.¹⁰ Strengthening value chain resilience and expanding domestic mining are now key elements of Europe's plan to regain competitiveness and reduce external dependencies.

To overcome these constraints, the EU must streamline regulation, enhance market incentives, and develop coordinated industrial policies that align energy resilience with long-term competitiveness. Doing so will help Europe preserve its innovation edge, protect strategic autonomy, and deliver on its climate commitments. Strengthening domestic capacity for clean technologies, reforming the permitting landscape, and integrating climate and economic policies will be essential.

Without solving the energy trilemma of security, affordability, and sustainability, Europe cannot remain an industrial power. It cannot credibly meet its climate goals either. And it cannot protect its economic sovereignty in a world shaped by technological rivalry and climate risk. Energy is no longer a background variable. It's the battlefield. And winning on this front means building an energy system that is cleaner, cheaper, and more sovereign, so that Europe can remain competitive, cohesive, and in control of its future.

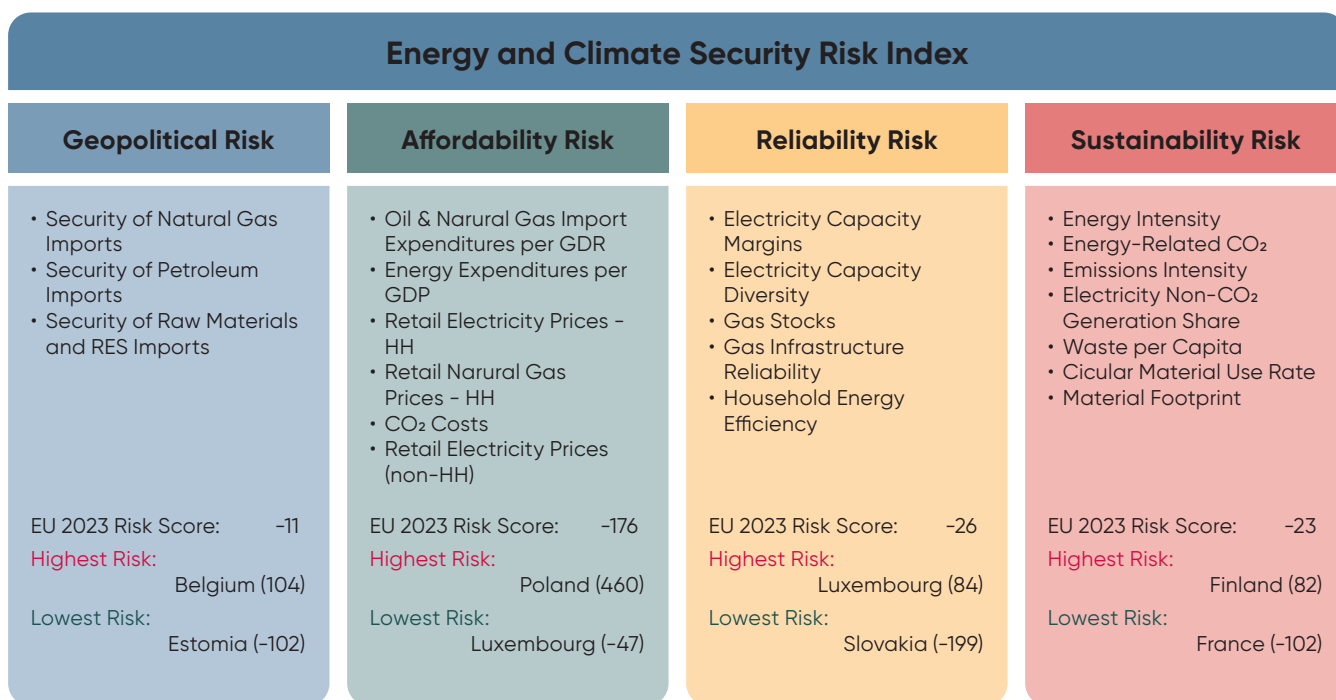
¹⁰ European Commission, [Strategic Framework for Economic Security](#), 2024.

MEASURING ENERGY AND CLIMATE SECURITY RISKS IN EUROPE

When Russia cut off much of its gas supply to Europe, it was not just energy markets that convulsed. Entire economic models started to shake. Suddenly, what had once been treated as technical energy policy such as grid balancing and marginal pricing, became core questions of Europe’s strategic survival: How can an advanced industrial economy compete when its energy costs are two to five times higher than those of its rivals? How can a continent decarbonize if it loses the industries needed to build clean infrastructure? And how can the EU reduce its external dependencies when it is replicating old vulnerabilities, this time not with fossil fuels from Russia, but with clean tech materials from China?

Integrating energy and climate security as a core pillar of the EU’s broader economic policy, while aligning it with decarbonization, market integration, and industrial competitiveness, is a prerequisite for managing systemic risk and unlocking future growth.

Figure 2. Dimensions of the Energy and Climate Security Risk Index¹¹



Source: CSD.

¹¹ Center for the Study of Democracy, Energy and Climate Security Risk Index.

Progress toward a coherent and resilient European energy policy has long been hampered by fragmented national approaches and uneven implementation. In this context, the **Energy and Climate Security Risk Index (ECSRI)** offers a critical tool to assess and benchmark national progress, identify vulnerabilities, and align policymaking across the Union. By facilitating a comparative, data-driven view of energy security, the ECSRI supports more effective coordination of national policies, backed by political, financial, and social commitments at both EU and member state levels.¹²

The ECSRI categorizes the vulnerability of each member state, and the EU as a whole, into four key dimensions of energy and climate security risk: geopolitical risks, affordability of energy consumption, reliability of energy supply, and sustainability of energy production and use. These dimensions reflect the most pressing concerns shaping the EU's energy future and allow for a comprehensive analysis of the Union's security posture across time.

The ECSRI provides not just a snapshot of risk, but a **dynamic framework** for evaluating how energy and climate security evolves over time. By monitoring the performance of member states across all four risk dimensions, it enables policymakers to trace the legacy of past decisions and assess which structural dependencies continue to expose their economies to external shocks. National and EU-level decision-makers need a reliable, transparent, and data-driven tool for understanding evolving energy and climate vulnerabilities. By equipping policymakers with this framework, the Index enhances the EU's ability to anticipate, respond to, and reduce risks, laying the foundation for more effective action at both the national and EU level.

As Europe continues to navigate a rapidly changing geopolitical environment, the ECSRI offers a crucial lens for aligning the continent's climate ambition with its economic and security imperatives. It underscores the reality that reducing energy and climate security risks is not only an environmental necessity, but a cornerstone of European sovereignty and long-term competitiveness.

On the surface, Europe has made progress. **The most acute geopolitical risk**, which had been the dependence on Russian fossil fuels, **has eased**. New LNG terminals have been built. Gas storage mandates have been strengthened. Import shares from EU allies such as Norway, Algeria, and the U.S. have risen. But this relative success has come at a steep price, and it has revealed a deeper imbalance.

¹² Vladimirov, M., Rangelova, K., and Dimitrova, A., *The Great Energy and Climate Security Divide: Accelerated Green Transition vs. the Kremlin Playbook in Europe*, Sofia: Center for the Study of Democracy, 2022. The ECSRI's beta version was launched in 2022 for 5 EU countries. The current version has been expanded to cover 25 EU countries (only Malta and Cyprus are missing due to lack of enough data). The Index' methodology builds upon the Index of U.S. Energy Security Risks developed by the The Global Energy Institute (GEI). However, it combines a much larger set of 20 indicators comprising thousands of data points that have been statistically tested through factor analysis and a DELPHI-method-based evaluation to ensure relevance and strong explanatory value.

Box 1. The Methodology

The ECSRI uses 20 indicators across 4 dimensions to measure each country's risk score.

Each indicator's risk score is standardised using the EU average and standard deviation from 2015 as reference values. The standardisation follows these steps:

1. The z-score is calculated as:
$$(\text{value in year } t - \text{EU-average in 2015}) / \text{EU-2015 standard deviation}$$
2. The resulting z-value is multiplied by 100 to express the risk score on a comparable scale.

A risk score of 0 indicates that a country's value for a given year matches the EU-average in 2015.

A score of +100 means the risk level is one standard deviation higher than the EU-average in 2015, while a score of -100 indicates it is one standard deviation lower. Higher values indicate that they are spread out over a wider range.

To calculate the dimensional risk scores and the overall ECSRI score, the individual indicator scores are aggregated using the geometric mean, with each indicator weighted equally.

The Index includes 20 normalized and interlinked risk indicators, compiled from thousands of data points covering the period from 2008 to 2023. These indicators form a holistic dataset capable of illustrating national vulnerabilities and EU-wide trends. While assigned to specific dimensions, these indicators are highly interconnected. For example, high levels of oil and gas consumption not only increase energy expenditures and emissions but also deepen geopolitical exposure.

To ensure comparability across countries and time, all indicators have been normalized to the EU-27 average in 2015, which serves as the baseline year. This year marks a critical inflection point – coming shortly after Russia's annexation of Crimea, when energy prices were low and an opportunity to diversify supply was missed. By using 2015 as a benchmark, the index not only captures shifts in risk levels but also reflects the consequences of inaction during a moment of strategic vulnerability for Europe.

Across the continent, **affordability risk has surged**. Electricity and gas prices remain dramatically higher than global benchmarks. Despite more renewables being added to the system, marginal pricing rules still peg electricity prices to volatile gas markets. For households in southern and eastern Europe, energy bills now exceed pre-crisis levels by 40–70%. For industry, the consequences

are more existential: plant closures, offshoring, and a new wave of job loss. Between 2021 and 2024, more than a million industrial jobs disappeared from Europe, not because of climate policy per se, but because of its incomplete implementation in an uncompetitive energy market environment.

System reliability, too, is splitting Europe in two. Wealthier countries with digitized, integrated grids in Northwest Europe are reinforcing supply resilience through demand-side management and diversified capacity. But in much of Central and Eastern Europe, outdated grids, inefficient district heating, and investment bottlenecks are leaving countries vulnerable. Here, the fear is not just affordability, but breakdown: of infrastructure, of public trust, of institutional capacity.

On sustainability, the picture is more mixed. Greenhouse gas emissions fell by 8% in 2023: a striking drop. But this was not the product of long-term technological change. It was the product of demand destruction. Industrial activity slowed, factories closed, energy consumption collapsed. As one German energy executive put it, “We didn’t decarbonize, we deindustrialized.” Sustainability gains built on economic decline are fragile and politically unsustainable.

Europe’s energy crisis is not over but it is evolving. The continent may have reduced its exposure to Russian gas, but it has not yet solved the deeper conundrum: **how to decarbonize** in a way that enhances, rather than erodes, economic competitiveness. That challenge is no longer theoretical. It is now the defining test of Europe’s ability to maintain strategic autonomy in an age of global fragmentation.

Countries that dominate the technologies of the clean energy will shape global trade, value chains, and diplomacy. If Europe cannot produce these technologies competitively, or at scale, then it will not be able to lead on climate, or protect itself economically.

There are lessons to draw from countries that have started to close this gap.

France has paired a clean energy push with grid reliability and domestic nuclear investment. **Denmark** has built an industrial ecosystem around offshore wind. **Poland**, which has been locked-in a decades-long coal dependence, has been rapidly transforming its energy system integrating massive amounts of wind generation, decentralized solar and heat pumps that have cut the share of coal in power generation in half.

Across Central and Eastern Europe, a state-driven nuclear revival is underway that aims to bridge the baseload gap left by uncompetitive coal plants and the geoeconomic reorientation of the region away from Russian nuclear dependence. What these examples share is not just climate ambition, but coherence: an alignment of energy, economic, and geopolitical priorities into a unified strategy.

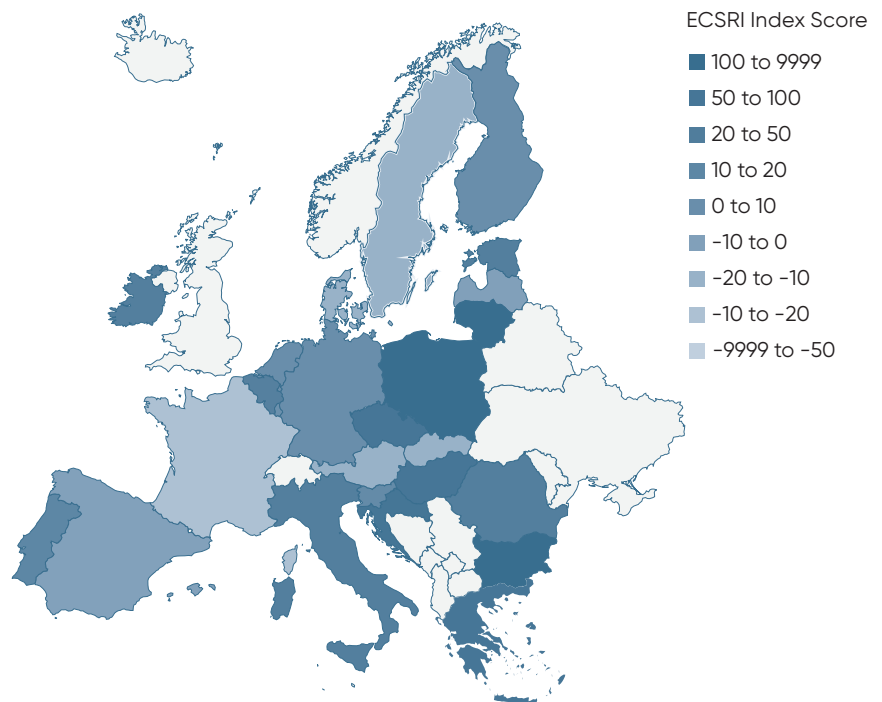
THE GREAT DIVIDE

The lack of sufficient coordination and the EU energy policy implementation gap has given leeway for individual European countries to carve out their own national strategic priorities even when they undermine the common EU ones.

Despite the establishment of the European Energy Union in 2015, the EU has failed to enforce a common approach to energy supply diversification, the reduction of energy use, and the transition to low-carbon energy technologies. The large gaps in member states' policies have hampered the EU goals of secure, affordable, and sustainable energy for Europe's citizens and businesses.¹³

At first glance, Europe's energy and climate ambitions appear aligned. The Green Deal, the Fit for 55 package, and REPowerEU all lay out clear, coordinated goals. The ECSRI reveals that while the EU has succeeded in setting ambitious climate targets and delivering large-scale renewable deployment, implementation remains deeply uneven. Member states diverge significantly in their exposure to geopolitical risk, affordability pressure, system reliability, and environmental sustainability.

Figure 3. Energy and Climate Security Risk Score across the EU



Source: CSD based on ECSRI data.

¹³ European Commission, *State of the Energy Union 2021*, Directorate-General for Energy, 2021.

The policy asymmetry spans all major energy issues. Take the thorny question about the **pace of decarbonization**. Western European countries such as Germany, Denmark, France and the Netherlands have built up institutional capacity to rapidly deploy renewable energy, modernize grids, and reform energy markets. In these countries, climate policy is an industrial strategy, backed by technical expertise, regulatory agility, and substantial public investment. Meanwhile, in many Central and Eastern European member states including Czechia, Hungary, Bulgaria and Romania, the transition remains tangled in economic anxieties, legacy infrastructure, and a lack of administrative capacity to absorb and implement EU funds effectively.

This divergence is not simply a question of ambition but it is also a reflection of **historical and structural differences**. Countries with a post-Soviet energy legacy often rely on coal-heavy power systems, single-source gas pipelines, and politically entrenched energy incumbents. Their transitions are constrained not just by cost, but by path dependency: the sunk political and economic capital of past decisions.

This policy gap is not closing. In fact, in some dimensions, it is widening. Take grid integration and interconnection: while Spain and Portugal continue to face bottlenecks in exporting surplus renewable electricity to France and Central Europe, the Baltic states are racing to synchronize their power systems with the continental European grid, breaking free from the Russian-controlled BRELL system.

The competitiveness divide is another key dimension of this issue. For countries that are heavily industrialized and energy-intensive, such as Germany and Italy, the transition to a low-carbon economy is seen as a competitiveness challenge. The shift towards cleaner energy sources often comes with higher costs, in terms of investment in renewable technologies and the cost of energy itself. While wealthier countries can afford to absorb these costs through subsidies or higher energy prices, many Eastern European nations, which face higher affordability risks, view such policies as threats to both economic and political stability. This has led to significant disparities in national energy security policies, where some countries prioritize energy affordability over decarbonization, while others focus on long-term sustainability goals without fully addressing immediate energy affordability concerns for their citizens.¹⁴

Affordability risks that have surged more than fivefold (Figure 3 below) in the past three years are the main drivers of energy policies in Europe. In the states where energy poverty remains high, and where citizens see climate measures primarily as additional costs, **decarbonization has remained politically fragile**. Policies like carbon pricing, energy taxation, or fossil fuel phaseouts have been much harder to defend if they are not accompanied by visible social compensation or reinvestment in local economies. This has weighed on the already strained budgets of many EU countries, which are looking for ways to bring down their fiscal deficits, often reaching to higher taxes for energy and fuels consumption.

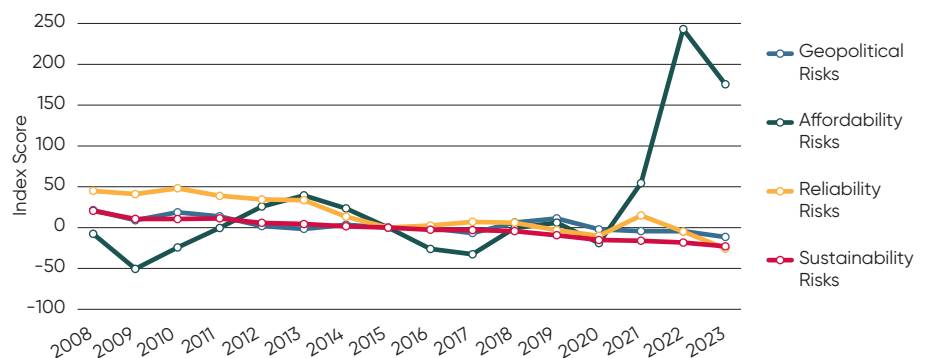
The paradox is that even when most low-carbon projects are market-driven and do not receive direct state backing, EU countries have seen an **erosion**

¹⁴ European Commission, [Energy poverty](#), Directorate-General for Energy (n.d.).

of the public legitimacy of the whole transition process. Even as the decarbonization of the energy system continues, there has been a marked slowdown in the improvement of the key sustainability pillar indicators. EU countries have kept on reducing their dependence on coal, and PV investment is setting new records each year. However, battery storage uptake has not been fast enough to secure affordable grid balancing, and wind energy projects have been delayed on the back of social backlash, slow permitting and increasingly costly supply chains.

Energy security policies further exacerbate the divide. While the EU as a whole seeks to diversify its energy supply and reduce dependency on external energy sources (as visible from the gradual decline of the geopolitical risks), member states take varying approaches to achieving this goal. Countries like Poland and the Baltic States have prioritized energy independence and security of supply, investing heavily in LNG terminals and interconnection infrastructure to reduce their reliance on imports from any single supplier, especially Russia. On the other hand, countries like Germany have been more focused on the energy transition but have, at times, been slower to diversify their energy sources due to political and economic constraints. This has left them vulnerable in moments of crisis, as was evident during the energy disruptions caused by the war in Ukraine. Since then, Germany reduced its Russian natural gas dependence from over 65% in 2021 to around 10% (via indirect imports from Belgium and Netherlands) by 2023 through strategic infrastructure developments.¹⁵

Figure 4. Geopolitical, Affordability, Reliability, and Sustainability Risk Pillars



Source: CSD based on ECSRI data.

An often-overlooked aspect of the transition is **material dependency**. While fossil fuel imports from Russia have declined, a new kind of vulnerability has emerged—one linked to the sourcing of critical raw materials and clean tech components. Countries that score lower on geopolitical risk are not just those that diversified their gas supply. They are the ones, which have begun to localise battery production, rare earth processing, and photovoltaic manufacturing. These are the countries preparing not only to decarbonize, but to decouple strategically from the dependence on authoritarian countries such as China or politically unstable suppliers in Africa and Latin America.

¹⁵ O'Sullivan, M. L., *Europe's messy Russian gas divorce*, Brookings Institution, 4 March 2024.

Vulnerabilities in one domain often spill over into others. For example, countries with high sustainability risks often also face affordability and geopolitical risks.¹⁶ Higher dependence on fossil fuels means higher electricity prices and dependence on unreliable suppliers while solar and wind are much more competitive on the market and are domestically sourced.

A cohesive European response will require **integrated strategies** that recognize these interlinkages, ensuring that all countries, not just the frontrunners, can progress toward a resilient, secure, and decarbonized energy future. Solving the energy trilemma at the national level is essential, but only a shared vision across the EU can close the Great Divide and secure lasting energy stability.

Finland, Austria, and Portugal demonstrate that it is possible to **align decarbonization with resilience**, to pair clean energy investment with social cohesion, to build trust by delivering results. What they share is not one perfect model but the political will and policy coherence to act on multiple fronts simultaneously. Europe cannot afford to treat these success stories as exceptions. If the energy transition is to be credible across the EU, it must become a shared capability, not just a shared ambition. That means closing the capacity gaps, accelerating knowledge and technology transfer, and designing EU policy frameworks that reward outcomes, not just formal commitments.

Strengthening Europe's resilience, innovation capacity, and sustainable growth is essential to **navigating global technological, climate, and geopolitical shifts**. Priorities include deepening the Single Market, scaling up technological leadership, upgrading workforce skills, and securing critical resources to enhance long-term competitiveness. Coordinated reforms and targeted investments are needed to overcome fragmentation, boost productivity, and accelerate the green and digital transitions.¹⁷

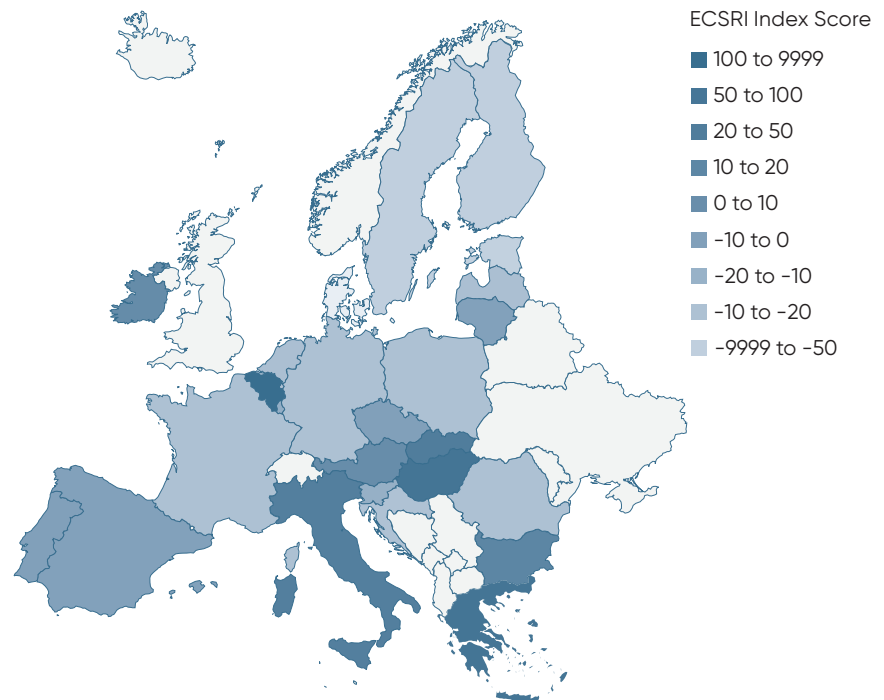
Geopolitical Risks

The Geopolitical pillar assesses a country's exposure to external geopolitical shocks based on its dependency on imported energy and raw materials. It captures vulnerabilities in oil, gas, and critical raw material supply chains, which are increasingly influenced by global market volatility and strategic competition. Key indicators include the security of petroleum imports, natural gas imports, and imports of raw materials and renewable energy sources (RES) components. Countries with more diverse energy sources and suppliers tend to face lower geopolitical risk, as they are less exposed to disruptions in any single supply route. While expanding renewable energy capacity helps reduce fossil fuel dependence, it also introduces new risks tied to the availability of critical materials for low-carbon technologies. As the green transition advances, securing stable, diversified, and geopolitically resilient supply chains for these inputs is becoming a central challenge to national energy security.

¹⁶ Vladimirov, Rangelova, and Dimitrova, *The Great Energy and Climate Security Divide*, Sofia: CSD, 2022.

¹⁷ European Commission, *The future of European competitiveness: A competitiveness strategy for Europe*, 2024.

Figure 5. Geopolitical Risks in the EU



Source: CSD based on ECSRI data.

Geopolitical risk is often treated as an abstract concept – something to be managed through diplomacy or buried in contingency plans. The energy trilemma is deeply shaped by geopolitical dynamics, particularly when it comes to **fossil fuel imports and energy system vulnerabilities**. Geopolitical risks, tied to the security of oil and gas reserves and import sources, play a pivotal role in determining a country's overall energy resilience. Countries highly dependent on imported fossil fuels from politically unstable or authoritarian regimes face heightened geopolitical risk, which often translates into increased affordability and sustainability challenges. For example, supply disruptions or deliberate manipulation can cause sharp price spikes, exacerbating affordability pressures for consumers and businesses. Additionally, reliance on fossil fuel imports threatens the reliability of the energy system and impedes sustainability progress, creating further vulnerabilities across the energy trilemma.

The continent's historical reliance on authoritarian states for fossil fuel imports, particularly from Russia, has underscored systemic vulnerabilities highlighted by Russia's annexation of Crimea in 2014 and the full-scale invasion of Ukraine in 2022. While geopolitical risks increased during these crises, the overall trend is a decrease in risk since 2008. As the EU continues to move towards more renewable energy generation and less reliance on fossil fuels from undemocratic regimes, this trend is expected to continue. The rapid decline in pipeline gas imports from Russia has shifted the structure of supply. LNG terminals across the continent have absorbed increased volumes from the United States, Norway, Qatar, and Algeria. Interconnection capacity has expanded. For the first time in decades, Russia is no longer the indispensable energy partner for Europe.

The Last Mile: The Sluggish Decoupling from Russian Energy

The rosy continental picture conceals deep national asymmetries. While the EU average geopolitical risk score has declined since the peak of the crisis in 2022, the range between member states remains wide, with some countries continuing to score high due to entrenched supply patterns, political choices, or underdeveloped infrastructure.

In 2023, Estonia, Finland, Denmark, and Sweden emerged as the top performers in the geopolitical risk dimension. Their strength lies in a combination of diversified import portfolios, access to seaborne LNG, and low reliance on fossil fuel imports from authoritarian regimes, in particular natural gas imports since natural gas makes up less than 10% of gross inland energy consumption in these countries.

- **Estonia** completed the full replacement of imports of Russian oil and natural gas in 2023. It is now importing Norwegian and US natural gas through Finland and Latvia and oil from alternative sources such as Kazakhstan. Its access to the Inčukalns underground gas storage facility in Latvia has been vital to replace Russian natural gas with LNG from terminals in Finland, Lithuania and Poland.
- **Finland** has nearly eliminated oil and gas imports from Russia, sourcing 57% of its oil from Norway and the rest from Sweden, the UK, and the U.S. Its gas now comes almost exclusively from Norway and the U.S., thanks to the commissioning of the Inkoo FSRU. Moreover, Finland's domestic production of key raw materials—including nickel and zinc—has reduced its exposure to Chinese and Russian-controlled supply chains for low-carbon technologies.

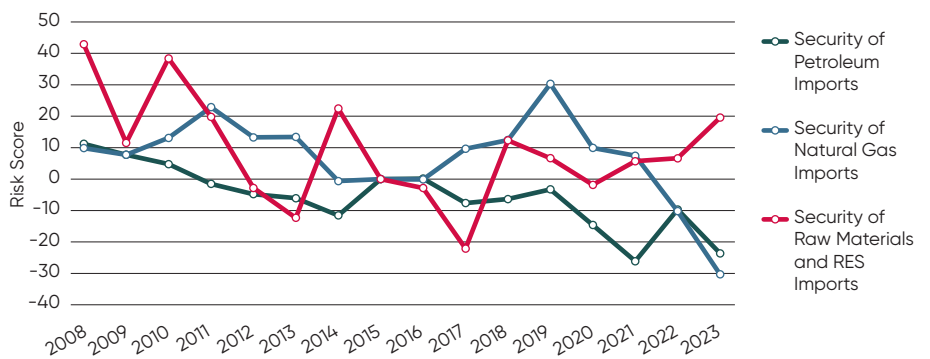
Denmark, with its robust wind generation, strong interconnections, and proactive investments in green hydrogen and grid flexibility, is charting a path toward full energy sovereignty. It also plays a key role in European wind turbine manufacturing, creating positive spill overs in terms of resilience.

At the other end of the spectrum, Hungary, Slovakia, and Austria recorded some of the highest geopolitical risk scores in the EU in 2023. These countries are not merely lagging; they remain structurally dependent on Russian energy, despite the war, sanctions, and the EU and U.S. pressure.

- **Hungary** imported over 75% of its gas from Russia in 2024, primarily via the TurkStream pipeline. Its state-owned utility, MVM, extended its contract with Gazprom in late 2024, doubling down on a bilateral relationship that actively resists the EU's collective energy strategy. As a result, Hungary's geopolitical risk score remains significantly above the EU average.
- **Slovakia** has taken steps to diversify its supply, including securing Norwegian gas via Czechia and LNG from Croatia. However, it remains functionally tied to Hungary's infrastructure, and in January 2025, it agreed to increase gas imports via Hungarian routes, effectively reinforcing its exposure to Russian supply.

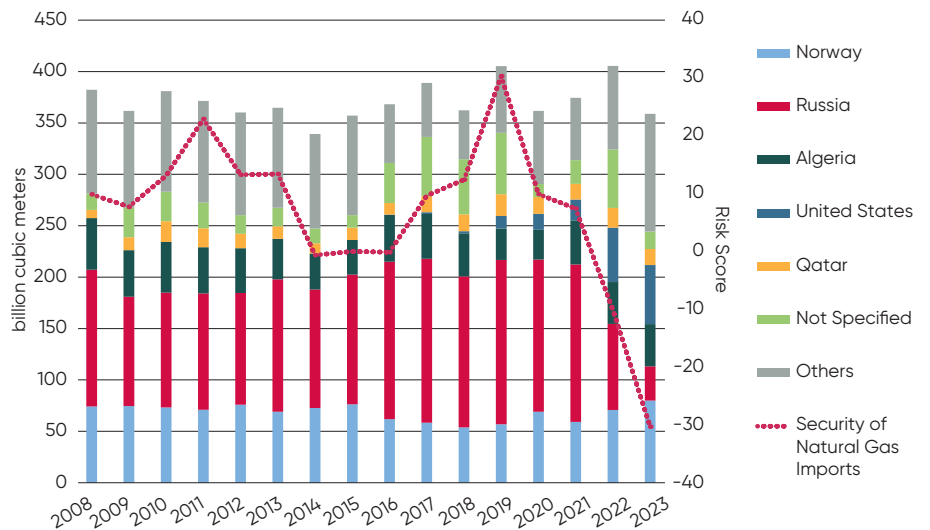
- Austria**, though politically aligned with the EU’s diversification goals, remains locked into long-term Gazprom contracts signed under legacy arrangements. While Russian pipeline gas imports fell sharply in 2022, they rebounded to cover nearly 80% of Austrian demand by 2024. Although Vienna has improved interconnections with Italy and Germany and secured Norwegian volumes, these measures have not yet structurally lowered its risk profile. The end of the Russian gas transit through Ukraine from 1 January, 2025 has meant that the country has ceased direct Russian gas imports but it remains unclear whether some indirect Russian gas purchases are still happening via the TurkStream pipeline.

Figure 6. Evolution of Geopolitical Risk Indicators in the EU



Source: CSD based on ECSRI data.

Figure 7. EU Natural Gas Imports by Country of Origin



Source: CSD based on ECSRI data.

As the EU moved away from importing natural gas solely from Russia and began to diversify its imports, the security of natural gas imports indicator dropped dramatically, leading to the overall reduction in geopolitical risks.

Yet, the efforts to mitigate geopolitical risks such as diversifying import sources, investing in LNG infrastructure, or increasing renewable energy sources often introduce short-term affordability trade-offs. The capital required to build resilient infrastructure and secure diversified supply chains can elevate energy costs, especially during transition periods.¹⁸

Box 2. Russian Gas Enablers in Europe

In 2023, Hungary, Slovakia, and Austria recorded the highest security risks for natural gas imports in the EU, primarily due to their continued reliance on Russian gas – a trend that remains largely unchanged today.

Hungary imported around 78% of its gas from Russia, and under Prime Minister Viktor Orbán, it has been the most resistant EU member state to decoupling from Russian energy. The government maintains that Russian gas is essential for Hungary's economy and energy security, with most imports arriving via the TurkStream pipeline through Bulgaria and Serbia. This dependency was reinforced in October 2024, when Hungarian state-owned energy group MVM signed a supplementary agreement with Gazprom to expand gas deliveries.¹⁹

Slovakia, while making efforts to diversify through agreements for Norwegian gas via Germany and Czechia and LNG from Croatia, remains closely tied to Hungary's supply routes. In January 2025, Hungary and Slovakia announced that Hungary would increase gas exports to Slovakia by nearly 1 billion cubic meters, effectively passing through additional Russian gas.

Austria has also been slow to shift away from Russian supply due to long-standing contracts with Gazprom. While Russian imports declined after the invasion of Ukraine, by 2024 they had rebounded to 80% of Austria's gas supply. A legal dispute between OMV and Gazprom in late 2024 led to an economic halt in direct contracts, but Russian gas continued to reach Austria via the spot market.²⁰ Although Austria has strengthened supply resilience by expanding LNG imports through Germany and Italy and securing Norwegian gas, its continued exposure to Russian supply chains – either directly or indirectly – underscores the vulnerability of many Central European countries. Whether Austria will now pivot fully to Western European gas or resume imports via TurkStream remains uncertain, but for all three countries, Russian gas continues to be a central feature of their energy security calculus, resulting in high geopolitical risk.

¹⁸ International Energy Agency, *Energy Technology Perspectives 2023: Energy supply chains between transition and disruption*, 2023.

¹⁹ Inotai, E., "Hungary turns itself into hub for Russian gas", *Balkan Insight*, 11 December 2024.

²⁰ Zhdannikov, D., and Schwarz-Goerlich, A., "Austria's half-century bond with Gazprom ended by gas seizure: Sources say", *Reuters*, 25 November 2024.

These investments are crucial to improving long-term energy security and reliability, as seen in the aftermath of the 2021 energy crisis, when market shocks linked to geopolitical tensions drove up prices across Europe. This crisis highlighted a key feedback loop: when geopolitical risks escalate and disrupts supply, affordability risks surge, particularly in countries with limited energy diversification. Strengthening energy security through a balanced and resilient energy mix is therefore essential – not only to reduce exposure to external shocks but also to stabilize energy markets and support the broader clean energy transition.

While the phaseout of Russian gas in the EU import mix has stalled since 2024, at the end of 2022, European countries banned all coal imports and most of the direct purchases of crude oil from Russia. However, the strength of the embargo has been undermined by some glaring loopholes including a direct exemption for Bulgaria until the end of 2024 and indefinitely for land-locked Central European countries including Hungary, Slovakia and Czechia. In-depth investigations have shown that all of these countries could replace Russian oil supply immediately but have instead maximised Russian imports leading to record-high profits for Russian oil companies and their local partners reselling the final petroleum products. After political and media pressure, Bulgaria and Czechia banned the imports of Russian oil in December 2023 and April 2025, respectively. However, Hungary and Slovakia keep on getting around 200,000 barrels of Russian crude per day via the Druzhba pipeline generating around \$4.3-4.5 billion per annum for the Kremlin.

At the same time, until the approval of the 18th sanctions package in July, 2025, the EU ban on Russian oil imports included also a **refining exemption**, which had allowed European countries to continue buying petroleum products from refineries outside the EU, such as India, Turkey and Egypt, which are importing large amounts of Russian crude oil. Greece, the Netherlands, Italy, Spain and Romania have been some of the biggest buyers of Russian-made petroleum products generating another \$8-10 billion in revenues for Russian companies each year.

In addition, **Greece** emerged as a critical enabler of Russian oil shipments not only through its vast fleet of tankers that have been moving around 20% of all Russian crude around the world but also as the most important hub for ship-to-ship transfers in the Laconian Gulf where Russian oil was transferred from one vessel to another in attempt to disguise the origin, price and destination of the oil shipment. The goal has been for Russian oil companies to sell their cargoes above the price cap of \$60 per barrel introduced by the G7 countries also in 2022.²¹

By the end of 2024, almost **80% of all Russian crude** was sold via the so-called **shadow tankers** that are owned by shippers and insured by companies registered outside of the G7. Between 2022 and 2024, Greek shipowners sold 127 tankers, over half of those entering Russia's shadow fleet, earning

²¹ Shentov, O., Stefanov, R., and Vladimirov, M., *The Kremlin Playbook in Europe*, Sofia: Center for the Study of Democracy, 2020.

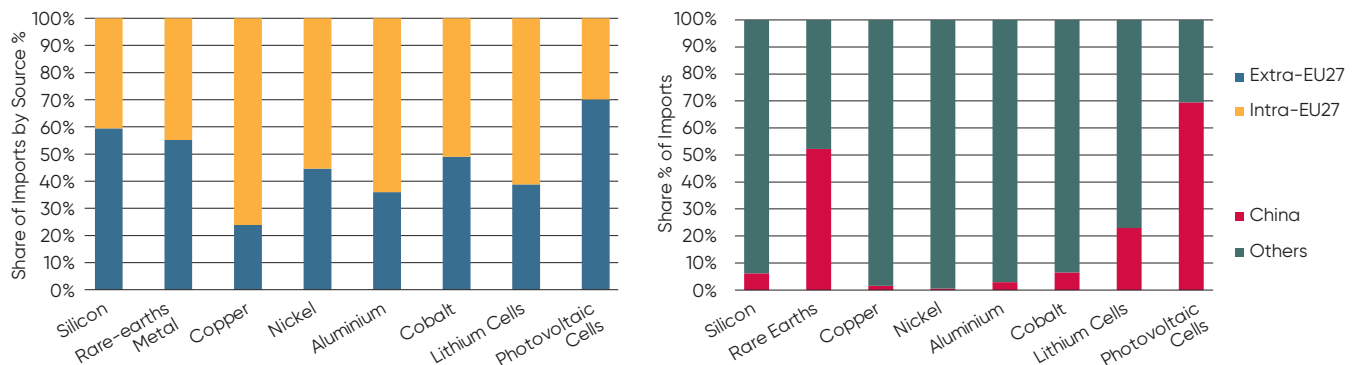
an estimated \$3.7 billion.²² The extensive use of ‘shadow’ tankers without proper insurance coverage has raised environmental and safety concerns, emphasizing the urgent need for comprehensive measures, including tighter enforcement of sanctions, banning imports from certain refineries, and targeting shadow tanker operations. The 18th sanctions package reduced the price cap to 15% below the average market price, which is likely to erode the Kremlin’s budget revenues from the sales of oil but at the same time will increase Russia’s appetite to amass an even bigger fleet of shadow tankers to continue circumventing the oil sanctions.

The New Layer of Risks: Critical Raw Materials

Even for countries that have cut Russian fossil fuels, a new form of geopolitical exposure has emerged: this time through the supply chains of the energy transition itself. The geopolitical risk pillar tracks not only fossil fuel dependencies but also the origin and processing concentration of clean tech inputs. In this sense, the Index is evolving to reflect the post-carbon geopolitics of energy security.

As Europe accelerates decarbonization, it is becoming over reliant on critical raw materials (CRMs) like lithium, cobalt, and rare earth elements. Most of these are refined, and in some cases entirely controlled, by China, which processes over 60% of global lithium and 80% of cobalt.²³ The European Commission has estimated that the demand for rare earth metals will increase 6 times by 2030 and the demand for lithium will increase 12 times by 2030.²⁴ The concentration of processing capabilities poses substantial threats to the EU’s supply chain resilience and industrial competitiveness, highlighting the urgent need for Europe to diversify its sources and invest in domestic processing capacities.

Figure 8. EU Import Dependence on Critical Raw Materials and on China



Source: CSD based on data from Eurostat.

²² Maragoudaki, D., and Triantafyllou, E., “Shadow fleet secrets: How Greek tankers were used to transport Russian oil. *Solomon*”, *Solomon*, 7 February 2025.

²³ Morace, C., “How tight is the Chinese grip on world’s metal supply”, *Quest Metals*, 18 March 2025.

²⁴ European Commission, *Critical Raw Materials Act*, 2024.

Countries that fail to mitigate this new dependency risk swapping one kind of strategic exposure for another. But some have started to decouple. In addition, several Northwestern European countries play key roles in the EU's supply of raw materials and renewable energy technologies, contributing to stronger security and lower risk profiles.

- **France**, for instance, leads the EU in silicon import security, thanks to domestic production and refining that supports solar panel and electronics manufacturing.
- **Sweden** accounts for 80–90% of the EU's iron ore production and has made key advances in extracting copper and zinc domestically.²⁵
- **Denmark** is the EU's leading exporter of wind turbines, reinforcing its status as a renewable energy hub and supporting the bloc's clean energy transition.²⁶
- **Portugal**, with Europe's largest lithium reserves, is scaling up green mining and refining, and is positioning itself to lead the battery value chains in the coming decade.
- **Finland**, hosts major facilities such as the Kokkola Zinc Smelter, one of Europe's largest, and the Harjavalta Nickel Refinery, a key node in the continent's nickel supply chain. This combination of energy diversification and raw material self-sufficiency contributes significantly to Finland's low risk profile.

What's notable across the dataset is that risk levels are not tightly correlated with geography or size, but rather with **policy direction and infrastructural choices**. To mitigate the emerging dependencies, Europe must prioritize nearshoring strategies, invest in domestic extraction and refining capacities, and diversify supply sources through stronger trade partnerships with politically stable, democratic allies. The European Commission's 2023 Critical Raw Materials Act and export control initiatives represent initial steps, but sustained political commitment and investment remain crucial.

Beyond the EU's borders, select neighboring countries offer opportunities for diversified, regional supply partnerships. **Serbia**, for instance, contains major lithium deposits and could become a low-cost, near-EU supplier of battery-grade materials. The Jadar mine, operated by Rio Tinto, contains an estimated 118 million tonnes of ore grading 1.8% lithium oxide. This deposit has the potential to meet up to 90% of Europe's current lithium needs. However, the project has faced environmental concerns and public opposition, leading to its suspension in 2022. As of mid-2024, the Serbian government has reinstated the possibility of lithium mining in the region.²⁷ **Ukraine** also holds substantial reserves of titanium, lithium, and rare earth elements, making it a potentially

²⁵ Vejgaard, S., *Economic value of the Swedish Mining Cluster – Today and in the future*, Copenhagen Economics, 2021.

²⁶ Green Power Denmark, *White paper: Wind energy, driving the global market*, State of Green, 2021.

²⁷ Dorđević, D. et al., "The influence of exploration activities of a potential lithium mine to the environment in Western Serbia", *Scientific Reports*, 14, 2024, Article 17090.

pivotal partner in the medium to long term. **Norway**, while not an EU member, is deeply integrated into European markets and offers secure sources of nickel, rare earths, and other raw materials under strong governance frameworks. The Fen Complex in southeast Norway is considered Europe's largest deposit of rare earth elements, with an estimated 8.8 million tonnes. This discovery is pivotal for Europe's green transition, reducing dependency on external suppliers.²⁸

No EU country is self-sufficient in raw materials for its clean tech ambitions. Strategic autonomy requires **investment in exploration, permitting, recycling, and substitution**.²⁹ To reduce long-term risk exposure, the EU should prioritize strategic alliances with countries that offer both resource potential and institutional alignment.³⁰ This includes forming multi-country supply and investment agreements with Nordic states, the Iberian Peninsula, the Western Balkans, and select Eastern Partnership countries such as Ukraine and Georgia.

These partnerships must go beyond extraction and include **processing, recycling, and infrastructure development** to ensure resilience across the full value chain. This includes scaling up domestic processing, refining, and recycling capacity to reduce dependency on external actors, particularly those with divergent strategic interests. The development of secondary raw material markets, supported by EU-wide standards and incentives, would not only limit the pressure on primary extraction but also align with broader circular economy goals. Strengthening transparency, traceability, and ESG standards in CRM supply chains through digital product passports or mandatory sustainability due diligence could also help ensure that diversification efforts do not simply shift vulnerabilities to other unstable or high-risk regions.

Importantly, the CRM challenge is not just about access, but about securing Europe's industrial competitiveness, especially in strategic sectors like electric vehicles, batteries, and clean tech manufacturing. If Europe fails to act, it risks replacing energy dependency with materials dependency—potentially undermining the very foundation of its green transition and exposing it to supply shocks and geopolitical coercion in a future defined by technological rivalry and resource scarcity.³¹

Europe's geopolitical risk landscape has transitioned from traditional fossil fuel dependencies towards new vulnerabilities linked to the clean energy transition. Addressing policy divides, strengthening domestic capabilities, closing sanction loopholes, and reinforcing secure supply chains, as measured by improvements across key indicators, will be essential for achieving Europe's energy security and climate objectives while increasing economic growth and competition linked to the new low-carbon system.

²⁸ Rare Earths Norway, *Europe's largest deposit of rare earth elements discovered at Fen, Norway*, 6 June 2024.

²⁹ European Commission, *Study on the Critical Raw Materials for the EU 2023 – Final Report*, Luxembourg: Publications Office of the European Union, 2023.

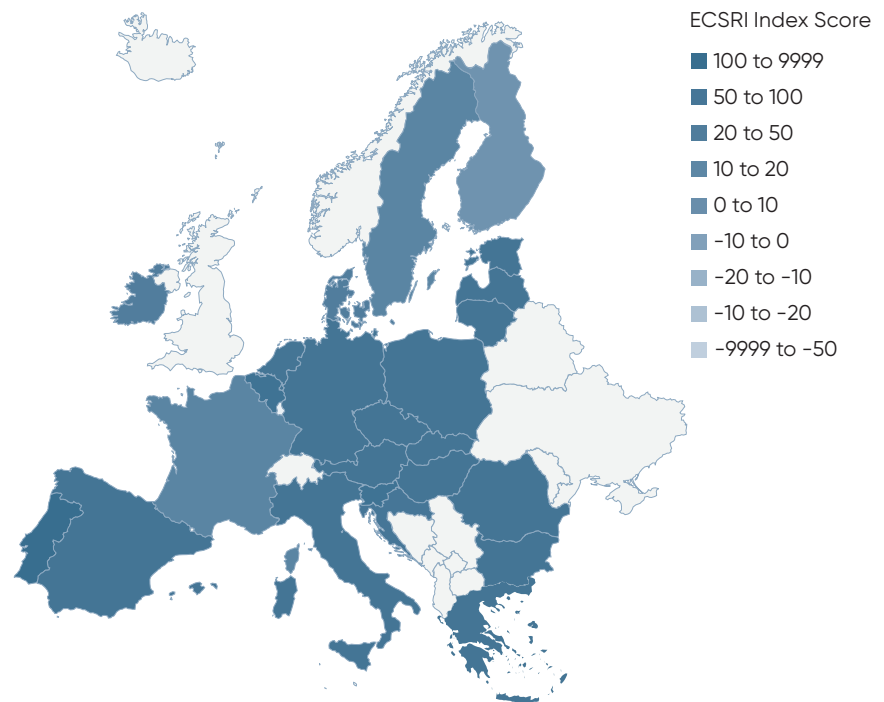
³⁰ Ragonnaud, G., "Securing the EU's supply of critical raw materials: The material nature of the EU's strategic goals", *Briefing*, European Parliamentary Research Service, PE 739.394, European Union, 2023.

³¹ Le Mouel, M., and Poitiers, N., *Why Europe's critical raw materials strategy has to be international*, Bruegel, 5 April 2023.

Affordability Risks

The affordability risk pillar of the Index evaluates the financial strain that energy systems place on national economies, businesses, and households. It captures both direct and indirect affordability risks by assessing energy prices, import expenditures, and the broader macroeconomic burden of energy consumption. Key indicators include household and industrial electricity and gas prices, oil and gas import expenditures relative to GDP, and overall energy expenditures. The sub-index also reflects how fuel mix choices, energy efficiency, and consumer behavior influence total energy costs. Carbon pricing further contributes to affordability risk, as economies with high CO₂ emissions intensity face greater financial exposure due to rising carbon costs. Together, these factors reveal how vulnerable countries are to energy-driven inflation, energy poverty, and competitiveness pressures.

Figure 9. Affordability Risks in the EU



Source: CSD based on ECSRI data.

Energy **affordability shapes the viability of entire industrial sectors**, the competitiveness of national economies, and the legitimacy of the green transition. If geopolitical risks are about external exposure, affordability risks are about internal stability, and in many parts of Europe, that stability is under strain.

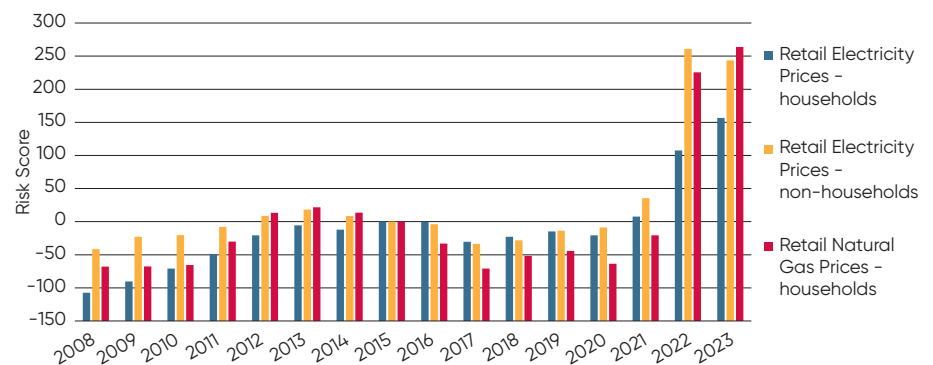
Countries with high affordability risks often also exhibit high vulnerability across these other dimensions, reflecting the deeply interconnected nature of energy systems. For example, states who are heavily reliant on imported fossil fuels not only face the risk of authoritarian governments using energy dependencies as a geopolitical tool, but also the economic fallout of price volatility, as seen during the energy crisis. These spikes had a direct impact on consumers and industries, particularly in countries previously almost solely dependent on Russian gas and with limited options for short-term supply

diversification or domestic production capacity, highlighting how geopolitical risks can rapidly amplify affordability risks.

While the shift toward renewable energy is essential for long-term sustainability, geopolitical independence, and lower electricity prices, it presents **affordability trade-offs in the short term**, which policymakers have used as an excuse to delay implementation. Transitioning to low-carbon technologies requires significant capital investments, which can temporarily drive-up electricity prices, straining public finances and increasing household energy burdens. Over time, as more renewable capacity comes online, energy prices begin to stabilize and decline, creating positive feedback loops that enhance affordability and security.³² However, managing the costs of this transition equitably will be essential to maintain public support and avoid backlash against much-needed climate and energy reforms.

Initially stable between 2008 and 2019, affordability risks surged sharply from 2020 to 2022 due to soaring energy prices driven by post-pandemic economic recovery, supply disruptions, and geopolitical tensions, particularly involving Russian gas supplies. The EU energy crisis was initially understood as a temporary emergency, driven by the Russian war, global supply bottlenecks, and underinvestment in fossil capacity. But the data from 2023 and early 2024 show that for many countries, high energy prices are becoming a long-term structural challenge. The average **retail electricity price for households in the EU increased by more than 30%** between 2021 and 2023, with some countries seeing far sharper spikes. While wholesale prices moderated in 2023, retail prices remained high due to the slow pass-through of cheaper contracts and the unwinding of state support schemes.

Figure 10. Risk Index for Average EU Retail Electricity and Gas Prices



Source: CSD based on ECSRI data.

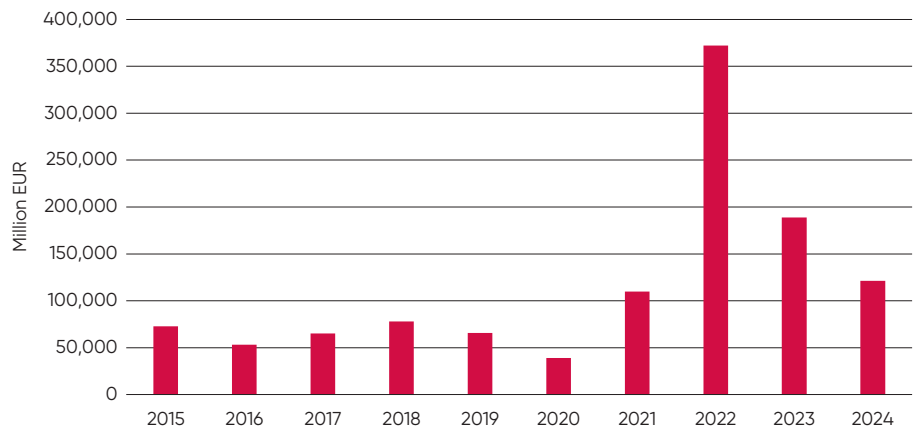
The energy crisis led to the doubling of affordability risks from 2021 to 2022. The main driver of the energy price surge was a strong economic rebound after the end of the COVID-19 lockdowns, which sharply increased energy demand, particularly for natural gas. However, supply remained constrained, partly due to underinvestment during the pandemic and deliberate reductions

³² Network for Greening the Financial System, *The green transition and the macroeconomy: a monetary policy perspective*, October 2024.

in gas exports from Russia. As demand surged and storage levels remained low, particularly for storage facilities fully or partially controlled by Gazprom, gas prices skyrocketed.

Due to the merit-order pricing structure of the EU electricity market, where the most expensive generation source needed to cover demand sets the final market price, soaring gas prices also drove electricity prices to historic highs across the continent.³³ Record-high gas prices also drove the European carbon price to unprecedented levels as they made coal-fired power generation comparatively cheaper than gas-fired power generation, which in return led to more demand for emissions allowances due to coal's higher emissions intensity. The EU member states that were able to cover demand with a combination of nuclear and renewable energy sources such as France, Sweden, Denmark and Finland, exhibited significantly lower price spikes.

Figure 11. Value of EU Natural Gas Imports in Million EUR



Source: CSD based on Eurostat data.

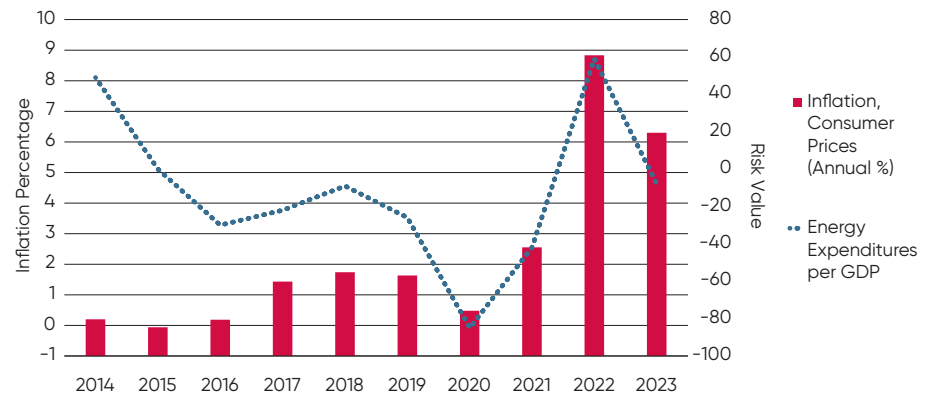
The combination of supply pressure, market design, and policy-driven price signals created the perfect storm, pushing both gas and electricity prices to levels that significantly strained households, industries, and public finances across the EU. This period saw significant increases in oil and natural gas import expenditures relative to GDP, highlighting Europe's vulnerability to external price shocks and energy supply disruptions. In 2022, the EU spent EUR 58 billion on average per month on energy imports, representing 22% of total EU imports, up from EUR 28 billion monthly for 14% of total imports in 2021.³⁴ The rise in inflation coincided with the increase in energy expenditures per GDP indicator, showing the extreme increase in affordability risk during the post-pandemic economic and energy crisis.

Governments responded with **price caps, subsidies, and tax reductions** although these measures strained the already overextended public finances

³³ Agency for the Cooperation of Energy Regulators, *ACER's preliminary assessment of Europe's high energy prices and the current wholesale electricity market design*, 2021.

³⁴ Eurostat, *EU imports of energy products – latest developments*, Statistics Explained, June 2025.

Figure 12. EU Inflation vs. Energy Expenditures per GDP



Source: CSD based on Eurostat data.

of many EU member states. The crisis underscored the need to accelerate the energy transition process and reduce the continent's reliance on Russian fossil fuel imports. Retail electricity and natural gas prices, especially for businesses, have underscored the urgency of transitioning towards a more stable and affordable energy system. High energy costs can undermine industrial competitiveness and constrain economic growth. Yet, policies aimed at enhancing energy efficiency, accelerating renewable energy deployment, and expanding grid infrastructure can alleviate these pressures, pointing towards a more competitive and growth-oriented economic future. Important EU legislation such as the REPowerEU Plan, RED III, and the EU Action Plan for Grids has helped to mobilize investment, with the EU investing \$360 billion in 2023 alone on renewable energy deployment and energy efficiency upgrades, up from \$267 billion in 2022.³⁵

Despite the **ambitious common EU action** on taking control of the crisis, there is no one-size-fits-all solution. Energy prices across Europe reflect deep structural differences in energy generation mixes and market designs. Countries, which are very dependent on fossil fuels for power generation such as Bulgaria, Czechia, Italy, Hungary, Croatia, and Poland report the highest electricity prices for non-household consumers, as the coal and gas power plants frequently act as price-setting technologies under the merit-order system.³⁶

These plants have to balance the power demand, particularly during high-consumption evening hours when solar output drops or during days with low wind speeds. As carbon prices rise, coal becomes increasingly expensive, compounding the upward pressure on wholesale prices. The household-level power prices do not always reflect the wholesale market trends in these EU member states due to different forms of price subsidies and regulations.

³⁵ Holman, R., and Siemplenski Lefort, J., "How the energy crisis sped up Europe's green transition", *Invested in Renewables*, European Investment Bank, 15 October 2024.

³⁶ Eurostat, *Electricity price statistics*, European Commission, April 2025.

In contrast, electricity prices are generally lowest in the EU countries where renewables and nuclear power typically determine the average day-ahead price. Among the **best performers** are Finland, France, Sweden, Portugal, Denmark and Spain.

Notably, Finland's commissioning of the Olkiluoto 3 nuclear reactor in 2023, following years of delay and cost overruns, expanded domestic electricity supply and allowed for greater exports to Estonia and Latvia, helping to reduce prices in those countries as well.³⁷ Thanks to abundant nuclear, wind, hydro, and biomass generation, Finland and Sweden have consistently maintained the lowest electricity prices in the EU, demonstrating the long-term affordability benefits of low-carbon baseload generation and the importance of the rapid addition of new renewable energy plants to the system.

France, in contrast, has benefitted from a more stable price environment, largely thanks to its nuclear fleet and the regulated tariff system (TRV). While the cost of maintaining and upgrading the ageing nuclear infrastructure is rising, France's relative insulation from gas volatility has kept its affordability risk score well below the EU average. This, in turn, has preserved a larger share of its industrial base and sustained public support for decarbonization policies.

Carbon Price Conundrum

The interplay between carbon prices and energy affordability has emerged as a **critical tension in the EU's climate policy** landscape. The requirement for carbon-intensive power plants to purchase EU Emission Trading Scheme (ETS) quotas has undermined the market competitiveness of fossil fuels. As the ETS quota price rises, industries dependent on coal, oil, and gas face escalating energy costs, creating a feedback loop where sustainability and affordability risks amplify one another. This is particularly evident in Central and Eastern Europe, where countries face high energy prices due to their continued reliance on fossil fuels and lagging renewable energy deployment.

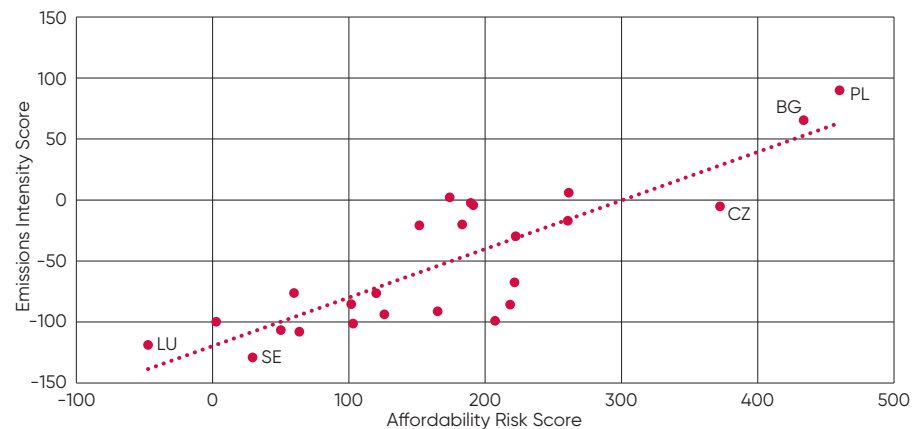
The strongest predictor of high affordability risks is the **emissions intensity of member states' economies** (see Figure 14), which is one of the six indicators in the sustainability dimension. Elevated emissions intensity rarely stems from underperformance in a single sector. Rather than stemming from one sector alone, high emissions intensity reflects broader structural inefficiencies such as outdated housing, inefficient heating, and legacy industrial systems.

The upcoming second phase of the ETS (ETS2), which will extend carbon pricing to road transport and buildings by 2027, has raised concerns that the additional carbon costs in emissions-intensive countries would further undermine the competitiveness of their economies. Czechia, backed by Poland, Slovakia, and Bulgaria, has called for a delay in the EU climate

³⁷ Nuclear Energy Agency, *The costs of decarbonisation: System costs with high shares of nuclear and renewables*, Organisation for Economic Co-operation and Development, 2019.

policy change to 2028, arguing that the premature implementation could strain household budgets and cripple the heavy industry. The CEE governments stress that their energy systems, still transitioning from Soviet-era infrastructure, lack the renewable capacity or grid flexibility to **absorb abrupt cost shocks without risking public backlash or industrial offshoring**.³⁸

Figure 13. Emission Intensity of the Economy and Affordability Risk (2023)



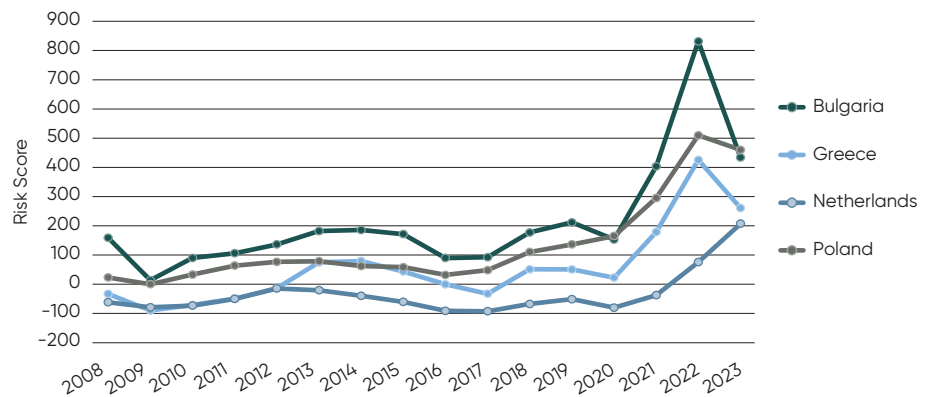
Source: CSD based on ECSRI data.

Box 3. Mitigating the Impact of Rising Carbon Costs

Phased carbon pricing, coupled with revenue redistribution mechanisms like the Social Climate Fund, can mitigate short-term affordability pressures while accelerating decarbonization. The Social Climate Fund can provide direct income support for vulnerable consumers, investments in energy efficiency measures, renewable energy uptake and low-carbon mobility. The EU member states should utilize the funds from the Fund to initiate a genuine transition in these sectors that are lagging behind instead of extending the practice of lavishly subsidizing fossil fuel industries. At the same time, higher energy prices could incentivize more affluent households to invest in energy efficiency improvements. Similarly, the Fund could be utilized to enhance public transportation in rural areas where households are excessively dependent on the use of private vehicles. For ETS2-skeptical states, the challenge lies in balancing legitimate socioeconomic safeguards with the urgent need to redirect fossil fuel subsidies toward clean tech and just transition policies. Over time, as clean energy deployment scales and carbon-intensive assets are retired, there will be a gradual decoupling between carbon costs and affordability risks.

³⁸ Plevák, O., "Czechia wants to delay ETS 2 until at least 2028", *Euractiv*, 17 December 2024.

Figure 14. Affordability Risks Across EU Member States with Carbon-Intensive Economies



Source: CSD based on ECSRI data.

Countries historically reliant on carbon-intensive sources have leveraged the potential economic opportunities emerging from strategic investments in renewable energy, infrastructure modernization, and technological innovation driven by decarbonization policies.

- Poland** has taken progressive steps toward a lower-carbon energy system. The country is rapidly scaling up renewables, particularly solar and wind, to reduce its dependence on coal while maintaining energy security. Between 2018 and 2023, Poland increased its installed onshore wind capacity by 55%, while solar capacity increased 45-fold. The country is also planning to install 5.9 GW of offshore wind by 2030. EU funds and national policies are driving investment in grid modernization and energy efficiency, helping to speed up the uptake of low-carbon technologies.³⁹ Additionally, Poland is committed to nuclear energy, with the aim of providing a stable, low-emission power source by the 2030s. This would reduce reliance on both coal and imported natural gas. While the transition remains complex, a combination of EU support, market incentives, and strategic investments is gradually steering Poland towards a more diversified and lower-carbon energy system, which can be used as an example for other carbon-intensive economies.
- Bulgaria** recorded the largest reduction in affordability risks among all EU member states in 2023. This notable improvement was driven primarily by the rapid expansion in solar power capacity, which grew by 79% between 2022 and 2023, followed by an additional 31% increase in 2024. The solar boom significantly displaced electricity generation from Bulgaria's highly polluting coal-fired power plants, which continue to operate only because of lavish state subsidies worth approximately €450 million per annum.⁴⁰ As a result, Bulgaria saw some of the sharpest declines in electricity prices.

³⁹ Kardaś, S., *From coal to consensus: Poland's energy transition and its European future*, Policy Brief, European Council on Foreign Relations, September 2023.

⁴⁰ Vladimirov, M. et al., *Accelerated lignite exit in Bulgaria, Romania and Greece*, Sofia: Center for the Study of Democracy, 2020.

es for non-household consumers across the EU, and carbon-related costs fell close to pre-crisis levels, although they still remain among the highest in the Union. Looking ahead, if Bulgaria were to emulate Poland's recent push to unlock its onshore and offshore wind potential, it could achieve even greater reductions in affordability risks, further enhancing the competitiveness of its economy and reinforcing long-term energy security.

- The **Netherlands'** drastic increase in affordability risks, on the other hand, highlights the link between import dependencies and affordability risks. The country's shift from domestic gas production to imported LNG underscored the importance of energy diversification for economic resilience. In 2023, the Netherlands experienced the largest increase in affordability risk among EU member states, even as most countries began to ease energy cost pressures. This spike was primarily driven by the near-total shutdown of domestic gas production from the Groningen field (Europe's largest) following years of public backlash caused by the increasing seismic activity linked to gas extraction. Groningen was a key source of low-cost domestic energy.⁴¹

As a result, the Netherlands became heavily reliant on expensive LNG imports and spot-market gas purchases, with its gas import share rising from virtually 0% in 2017 to 65% by 2023. Natural gas import expenditures more than tripled between 2021 and 2023, sharply increasing energy costs across the economy. Affordability pressures were further intensified by the early phase-out of government subsidies. The household price cap introduced in 2022 was both less generous and shorter-lived, and the VAT on energy returned to 21% in 2023, adding to already elevated bills. These impacts were particularly acute given that over 90% of Dutch households rely on natural gas for heating, making consumers especially vulnerable to price fluctuations.⁴²

Improving energy affordability in Europe requires a **dual approach**: targeted short-term relief and systemic long-term reforms. In the near term, policy tools such as temporary price caps, energy bill subsidies, and social tariffs can **shield vulnerable consumers from price volatility**, but these must be carefully designed to avoid distorting market signals or deterring investment. Over the long term, affordability hinges on structural investments in renewable energy, energy efficiency, and grid modernization, all of which reduce dependence on volatile fossil fuel markets and lower marginal energy costs over time. Expanding building renovation programs, deploying demand-side flexibility, and scaling up distributed energy resources like rooftop solar can empower consumers to actively lower their own costs. At the same time, **improving price transparency, market integration, and regulatory coordination** across EU member states can help ensure that price signals reflect the true cost of energy while minimizing regional disparities. Crucially, these measures must be accompanied by robust social policy frameworks that protect households during the transition and ensure public support for the energy transformation ahead.

⁴¹ European Commission, Directorate-General for Economic and Financial Affairs, *2023 Country Report – Netherlands*, Institutional Paper 243, 2023.

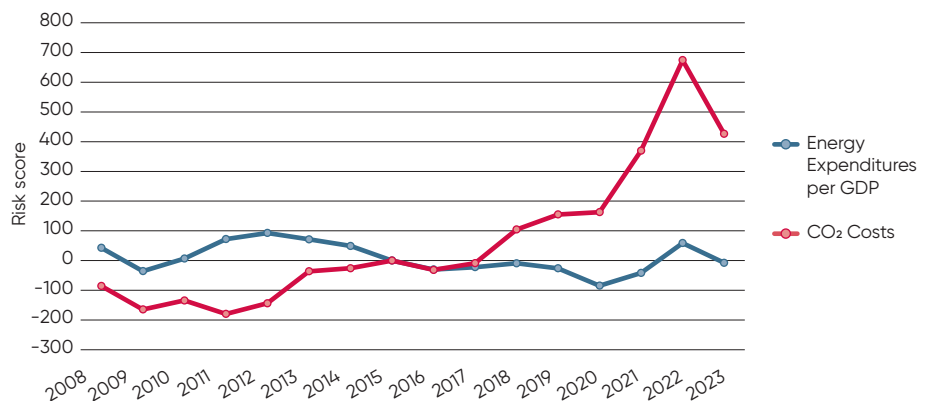
⁴² OECD, *Decarbonising Homes in Cities in the Netherlands: A Neighbourhood Approach*, OECD Regional Development Papers, 2023.

What the ECSRI reveals is that affordability risk is not only determined by market prices but is also shaped by **institutional choices**. Countries that intervened decisively during the crisis, but also set out a path for structural reform, have fared better than those that relied on ad hoc subsidies without reconfiguring their market frameworks.

The Baltic states, for example, used the crisis to **accelerate market reforms**. Lithuania combined temporary price caps with long-term contracts for green electricity, expanding local renewables while avoiding unsustainable fiscal burdens. Estonia created a windfall tax framework for energy firms that channeled excess profits into grid upgrades and compensation for vulnerable consumers—reducing risk without distorting price signals.

In contrast, Croatia and Slovakia extended **blanket subsidies** that kept consumer prices artificially low but created major imbalances in public budgets and investor confidence. In both cases, long-term PPAs and renewable auctions have stalled, and energy poverty remains a politically toxic issue.

Figure 15. Energy Expenditures Intensity and CO₂ Costs



Source: CSD based on ECSRI data.

Affordability is no longer a secondary policy challenge but is a **primary constraint** on Europe's ability to decarbonize while maintaining cohesion and productivity. It affects not only citizens' trust, but also the capacity of businesses to compete globally. And unlike the geopolitical risks that can sometimes be insulated through infrastructure or contracts, affordability risk sits at the heart of how energy markets function, and who they serve. For Europe to succeed in the next phase of its energy transition, it must ensure that clean energy is not only available, but accessible and economically viable for all. Otherwise, the gap between ambition and reality will only grow, and the divide between energy leaders and energy laggards will harden.

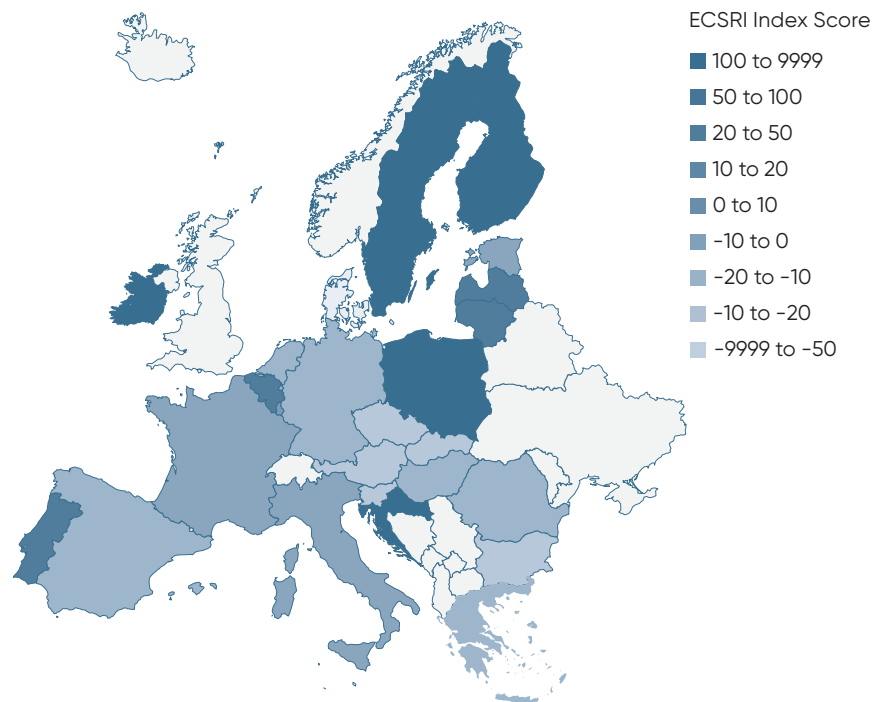
Across the EU, parties skeptical of climate policy have gained traction by linking high energy prices to Brussels-driven regulation. For example, in Czechia, anti-EU populist parties explicitly blamed the Fit for 55 package for rising household bills during the 2023 municipal elections. In Poland, the Law and Justice Party's energy populism remains a key pillar of its

electoral strategy, despite growing EU pressure on fossil subsidies. Even Germany, which has been the most dedicated leader of the cross-European decarbonization path, has seen both mainstream and extremist parties protest against the EU energy transition policy framework. Unless affordability is addressed in structural terms, i.e. not just through stopgap subsidies, but through deep market redesign and investment in decentralized, cheaper clean energy, the legitimacy of the transition will remain fragile.

Reliability Risks

This pillar assesses a nation's resilience to energy supply disruptions and its capacity to maintain stable energy flows during crises. It evaluates infrastructure robustness (e.g., energy storage, electricity capacity margins, and gas infrastructure reliability), demand-side adaptability (household energy efficiency), and risks from over-reliance on single suppliers or vulnerable trade routes. The risks to the electricity and gas systems are particularly relevant in the context of increasing electrification, high volatility in the supply and price of natural gas, and more frequent extreme weather events.

Figure 16. Reliability Risks in the EU

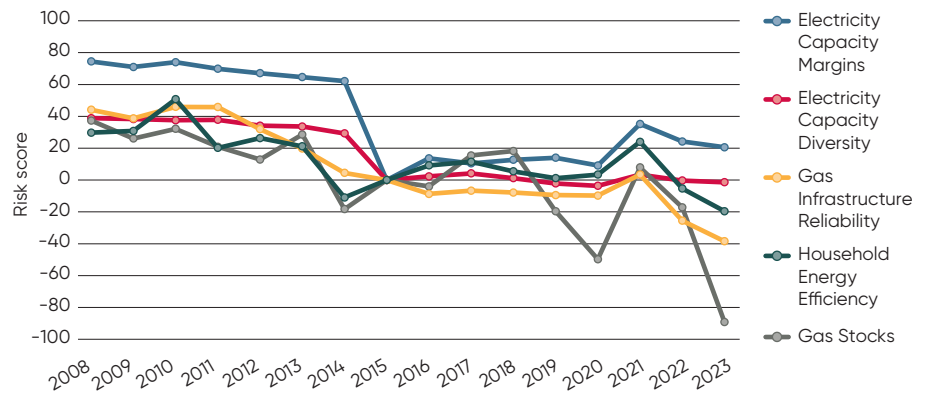


Source: CSD based on ECSRI data.

If affordability risk is about the cost of energy, reliability is about its consistency—and its absence often becomes visible only in moments of failure: blackouts, grid congestion, curtailment of renewables, or slow restoration times after outages. The ECSRI reveals that while most of the EU has improved system reliability since the early 2010s, risks persist, and in some cases are rising again due to uneven investment in infrastructure modernisation and digitalisation. Countries with smaller populations or limited infrastructure

tend to score worse on this dimension, often due to geographical constraints or systemic dependencies on single sources of supply.

Figure 17. Reliability Risk Indicators



Source: CSD based on ECSRI data.

The **countries that perform best** in the reliability dimension are France, and the Netherlands, which share one key feature: a generation portfolios that ensure flexibility in the face of demand surges or intermittent renewable supply.

- **France**, despite ongoing challenges with its ageing nuclear fleet, still benefits from a unique position in Europe's grid: it is a major exporter of electricity and has a high level of system redundancy. Its reliance on baseload nuclear, combined with a growing share of renewables and strong interconnectivity with neighbouring countries, keeps its reliability risk well below the EU average.
- **The Netherlands** has heavily invested in digital monitoring, automated dispatch systems, and real-time market balancing. While its generation capacity is increasingly reliant on offshore wind, it has managed to avoid major stability issues by scaling up demand-side response and storage capacity in parallel.

On the other side of the spectrum are **Luxembourg, Finland, Poland, Croatia and Ireland**, which recorded some of the highest reliability risk scores in the EU. However, these rankings must be interpreted in context. Luxembourg, for example, lacks significant gas storage or power generation capacity within its borders, but this reflects strategic reliance on cross-border infrastructure rather than systemic vulnerability. The country enjoys access to gas storages and LNG terminals in Germany, Belgium, and France, LNG terminals in nearby countries, and is part of the highly integrated German-Austrian electricity market.⁴³ In this context, large domestic investments in energy infrastructure would be inefficient and redundant.

⁴³ The Luxembourg Government, [Luxembourg's Integrated National Energy and Climate Plan for 2021-2030](#), Last update 23 October 2024.

- **Ireland's** high reliability risk is primarily driven by its geographical isolation. The country lacks both gas storage and LNG import terminals and relies entirely on pipeline imports from the United Kingdom.⁴⁴ This limited connectivity results in elevated risk scores for gas stocks and infrastructure reliability. While such vulnerabilities are difficult to address due to geographical constraints, they highlight the importance of long-term diversification strategies, especially for island nations.
- In **Finland**, the reliability risk stems less from infrastructure gaps and more from the country's low level of household energy efficiency – the lowest in the EU. The long heating season, stretching six to eight months in many areas, significantly drives up energy use. In addition, many households still rely on firewood for heating, which further compounds the inefficiency and contributes to the country's elevated risk score.
- **Croatia** presents a more distinct case. In 2023, the country's risk scores for electricity capacity margins, generation diversity, gas stocks, and gas infrastructure reliability were all above the EU average. Despite an improvement in capacity margins, due in part to new solar and wind installations, Croatia's derated generation capacity only barely exceeded peak demand. In both 2021 and 2022, it failed to meet peak demand without substantial imports. Although imports declined from 28.5% of electricity consumption in 2022 to 12.2% in 2023, the country remains vulnerable to power shortages. The electricity mix is heavily reliant on variable and volatile hydro power production (around 50%), followed by onshore wind and natural gas. Given the worsening climate variability in the Western Balkans, droughts and heatwaves have increasingly undermined Croatia's energy reliability. The country's plans to diversify by developing offshore wind capacity, targeting 0.51 GW by 2030 and 3 GW by 2050, are crucial in mitigating future risks. Gas infrastructure has improved following the commissioning of the Krk LNG terminal in 2021, but due to the limited size of the national gas storage facility and an uptick in natural gas consumption in 2023, Croatia's risk score is still high and increasing.
- **Poland** stands out as the only large economy among those with the highest reliability risk scores. Its energy system remains heavily dependent on coal, which made up 50% of the total installed capacity in 2023. Only Germany has more installed coal capacity, but coal constitutes a far smaller share of the German energy mix. Poland's coal sector, which employs around 75,000 workers, has been historically subsidized and politically protected, making its phaseout socially and economically sensitive. Although Poland is set to receive €3.5 billion from the EU's Just Transition Fund to support affected regions, its transition remains complex. While there has been promising growth in solar and onshore wind, the expansion of gas-fired generation risks locking the country into a new form of fossil fuel dependency.⁴⁵

⁴⁴ Sustainable Energy Authority of Ireland, *Energy security in Ireland: 2020 Report*, September 2020.

⁴⁵ Śniegocki, A. et al., *Just Transition in Poland: A Review of Public Policies to Assist Polish Coal Communities in Transition*, Report 22-06, Resources for the Future, 2022.

Infrastructure investments, such as the Dolna Odra gas plant expansion and LNG terminals like Świnoujście, have long payback periods and could become stranded assets under future EU regulations and global carbon pricing schemes. In 2023, Poland was also one of the few countries where the gas stock risk increased, despite EU-wide regulations mandating higher storage levels. Its average annual storage filling level fell from 87% in 2022 to 80% in 2023. Combined with relatively low storage capacity compared to national demand, this makes Poland's planned reliance on gas for electricity generation especially risky. On a more positive note, Poland's gas infrastructure reliability has improved significantly since 2008, thanks to the LNG and storage investments, although infrastructure development still lags behind demand growth.

Gas Supply Reliability

The **gas infrastructure reliability** indicator tends to penalise countries with limited infrastructure, even when gas plays a marginal role in their energy systems. Ireland, Sweden, Estonia, Portugal, and Slovenia all rank poorly on this indicator. Yet in countries like Sweden, where natural gas accounts for just 1.6% of energy consumption, the reliability risk is more theoretical than real. Sweden is only connected to Denmark via pipeline and has only one small LNG regasification terminal. In the event of a pipeline disruption, Sweden would struggle to cover its consumption needs. However, its negligible dependence on natural gas, coupled with strong performance on other energy indicators, mitigates this risk. A similar story applies to Portugal and Slovenia. Portugal has an LNG terminal but otherwise can only import natural gas from Spain. The Iberian Peninsula remains relatively isolated from the rest of the EU gas market, a structural issue that has more adverse security of supply effects on other EU countries as they cannot make use of Spain's large LNG import capacity. Slovenia, on the other hand, is heavily reliant on a single pipeline from Austria, which contributes 72% of its total gas import capacity. While the country also has interconnectors with Italy and Croatia, the heavy dependence on one corridor leaves it exposed to potential disruptions.

Paradoxically, **countries with robust gas infrastructure often fail to leverage it to reduce import risks**, while states with weaker systems achieve greater supply diversification (Figure 18). Slovakia, Austria, and Hungary, historically central hubs in Russian gas transit networks, exemplify this disconnect. Despite their low gas infrastructure reliability risks (stemming from extensive pipeline networks and storage facilities), all three retain some of the highest security of natural gas imports risks because they continue sourcing most of their gas from an unreliable supplier such as Russia via alternative routes like TurkStream. This reliance persists even as alternatives – e.g. Norwegian pipeline gas via Germany, LNG from Italy's Adriatic terminals, or Croatia's Krk LNG facility – remain underutilized.

Box 4. The Kremlin Playbook for Undermining the Reliability of Supply

Russia's deliberate curtailment of gas supplies to Europe in 2021, aimed at depleting regional storage reserves, precipitated a continent-wide crisis that erased years of progress in gas infrastructure resilience. By leveraging its role as a dominant gas supplier in Central European storage facilities, notably in Austria, Slovakia, Hungary, and Germany, Gazprom exacerbated the EU's structural reliability vulnerabilities, triggering a 58-point surge in EU-wide gas stock risks. The Kremlin's tactics exposed the structural fragility of over-reliance on a single supplier and underscored systemic gaps in storage preparedness.

In response, the EU's 2022 Gas Storage Regulation proved pivotal. Mandating member states to refill gas storages to 80% by November 2022 and 90% by November 2023, the policy rapidly reversed risks, driving a sharp decline in the gas stock risk indicator by 2023.⁴⁶ Complementing these measures, strategic infrastructure investments (including Germany's expedited commissioning of LNG terminals at Wilhelmshaven and Brunsbüttel, and France's expanded regasification capacity at Dunkirk and Fos-sur-Mer) bolstered Europe's ability to diversify gas sources and absorb shocks. Since February 2022, the LNG regasification capacity in the EU has expanded by 50 bcm to facilitate the surge in LNG imports.⁴⁷

Coupled with surging LNG imports, these efforts not only mitigated immediate supply risks but also laid the groundwork for long-term economic stability, insulating markets from future geopolitical disruptions. The crisis underscored a critical lesson: regulatory foresight and infrastructure resilience are indispensable to energy security. While the 2021 shock tested Europe's preparedness, the subsequent policy-industrial alignment demonstrates the bloc's capacity to adapt and fortify its energy systems against adversarial tactics.⁴⁸

By contrast, Portugal, Estonia, and Slovenia, despite scoring poorly on gas infrastructure reliability due to single-point dependencies have markedly lower import security risks. Portugal's strategic use of diversified LNG suppliers (e.g., U.S., Nigeria) demonstrates how proactive sourcing can

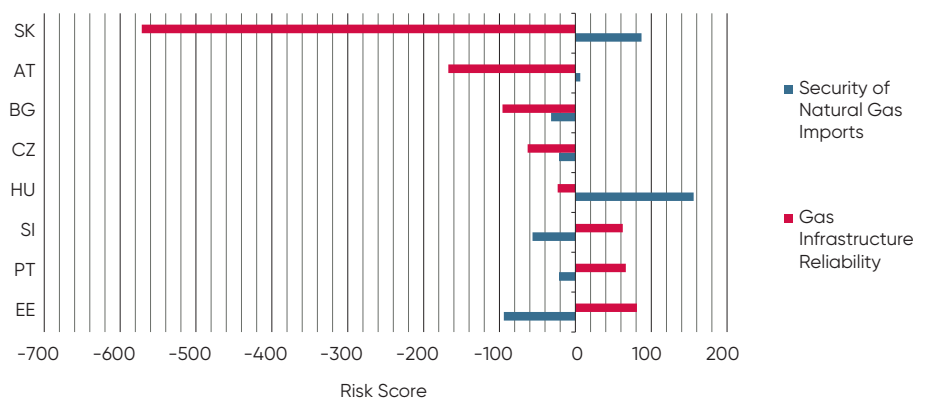
⁴⁶ European Union, [Regulation \(EU\) 2022/1032 of the European Parliament and of the Council of 29 June 2022 amending Regulations \(EU\) 2017/1938 and \(EC\) No 715/2009 with regard to gas storage](#), OJ L 173, 30.6.2022, p. 17–33, 2022.

⁴⁷ European Union Agency for the Cooperation of Energy Regulators, *Analysis of the European LNG market developments: 2024 Market Monitoring Report*, 2024.

⁴⁸ This progress underscores extensive investments in pipelines, storage, and regasification terminals, facilitating diversified gas sources beyond traditional suppliers such as Russia. Poland's Baltic Pipe project and the expansion of its Świnoujście LNG terminal exemplify such regional initiatives, significantly enhancing energy security and economic resilience in Central Europe. Poland's Baltic Pipe project connects Poland, Denmark, and Norway, providing 10 bcm of gas annually, thus lowering the reliability risk for all three nations due to this secure gas supply decoupled from Russian supplies. Voytyuk, O., "The Baltic Pipe and its impact on energy security in Central and Eastern Europe", *Polityka Energetyczna – Energy Policy Journal*, 25(1), 2022, pp. 89-108.

offset infrastructure limitations. Czechia further illustrates the potential for infrastructural adaptation. By reversing flow directions on pipelines, previously used for imports from Russia, it purchased 87% of its gas from Norway via Germany in 2023, slashing its import security risk by 69 points compared to 2022. This model proves that even infrastructure originally designed for Russian gas can be repurposed to enhance resilience, a lesson yet to be embraced by Hungary and Slovakia, where geopolitical alignment continues to outweigh energy security pragmatism.

Figure 18. Gas Infrastructure Reliability Does Not Always Mean Security of Supply



Source: CSD based on the ECSRI data.

Renewable Integration Without the Infrastructure Backbone

The rapid deployment of renewables without corresponding grid upgrades is becoming a major source of reliability risks. Europe’s renewable energy transition has reached a pivotal juncture, where the capacity of power grids to integrate wind and solar generation now poses as critical a challenge as the deployment of the technologies themselves. While wind and solar capacity has expanded rapidly, grid congestion and aging infrastructure increasingly bottleneck their potential.

In Germany, for instance, 10 TWh of renewable energy was curtailed in 2023 due to transmission constraints⁴⁹, primarily along the north-south divide where wind-rich northern states struggle to supply industrial hubs like Bavaria. Similarly, Denmark, despite generating enough electricity from wind to supply also neighboring countries, faces recurring export limitations when its interconnectors to Norway and Germany reach capacity during peak production. Grid congestion management has imposed a significant financial burden on the EU’s two largest economies – Germany and France – costing approximately €293 million in 2024, an increase of €202 million compared to 2019.

⁴⁹ ESFORIN, “Grid curtailment in Germany”, *Blog*, 26 March 2024.

This sharp rise reflects growing inefficiencies in the electricity market, which prioritizes economic over geographic optimization. As a result, low-cost renewable energy is often generated far from major demand centers. To maintain grid stability, transmission system operators (TSOs) are frequently forced to curtail output from RES while ramping up production from dispatchable plants – typically gas-fired – located closer to where electricity is needed. TSOs must cover both the compensation for curtailed RES production and the higher costs of activating alternative generation.

Box 5. The Iberian Peninsula Blackout: A Warning for High-Renewables Grids

On 28 April 2025, at precisely 12:33 PM CEST, the Iberian Peninsula's electricity system collapsed. In under five seconds, nearly 15 GW of solar generation, which is about 60% of total demand, was lost, following the near-simultaneous disconnection of two large solar farms in southwestern Spain. Spain and Portugal were electrically islanded from the rest of the European grid, triggering a cascading blackout that lasted for several hours⁵⁰.

Unlike previous blackout events, this failure occurred in stable weather conditions. It was not renewables per se that failed, but the lack of system readiness to integrate large-scale inverter-based generation without proper voltage support, inertia, and grid-forming backup. According to Spain's grid operator REE, the event exposed significant vulnerabilities in grid stability due to insufficient synchronous generation and reactive power, with renewables supplying more than 78% of electricity at the time. The blackout became a defining case of the risks of high renewable energy-based systems operated on legacy grid architectures.

In response, the Spanish and Portuguese governments announced over €800 million in urgent investment for new synchronous condensers, grid-forming inverters, and fast-responding storage⁵¹. Plans also include interconnection expansion with France and Morocco, the installation of black-start units for critical facilities, and improved grid flexibility forecasts. This event illustrates that grid reliability is no longer just about generation adequacy.

The whole system architecture should be strengthened and redesigned for the challenges of a fully-decarbonized power grid. As Europe accelerates renewables deployment, it must equally invest in the tools that keep the system balanced and safe under stress.

⁵⁰ Hevia-Koch, P., and Wanner, B., "The Iberian blackout has highlighted the critical importance of electricity security", Paris: International Energy Agency, 16 June 2025.

⁵¹ Goncalves, S., "Portugal to invest \$466 million to boost grid management, battery storage after outage", *Reuters*, 28 July 2025; Spain, Ministry of Ecologic Transition, *El Gobierno aumenta la resiliencia de la red de transporte de energía eléctrica* [Press Release: The Government improves the resilience of the power transmission network], 8 July 2025.

The surge in congestion management costs points to systemic weaknesses in the current market and grid design. Contributing factors include insufficient RES capacity near demand hubs, limited transmission infrastructure, and, as highlighted by ENTSO-E in its most recent Bidding Zone Review, a suboptimal configuration of bidding zones. For example, for Germany, ENTSO-E identified that splitting the existing Germany–Luxembourg bidding zone into five smaller zones would yield the highest net economic benefit, suggesting that more granular market segmentation could enhance overall efficiency.

Adding to the challenge, some of the most critical nodes in the integrated European power grid – including Germany, France, Czechia, Poland, and Hungary – have among the shortest total lengths of transmission lines relative to their peak electricity demand. This limited grid density constrains the ability to flexibly reroute power and integrate renewable generation across borders, exacerbating regional imbalances and increasing reliance on costly short-term interventions. These inefficiencies further underscore the urgent need for accelerated grid modernization, including high-voltage direct-current (HVDC) corridors, and distributed storage solutions to balance supply-demand mismatches.

Despite the structural vulnerabilities of the European power grid, the overall **European electricity capacity margins have strengthened significantly** since 2008, even as European countries have accelerated the early retirement of coal and nuclear plants and the integration of renewable energy sources, whose intermittent output necessitates derating their capacity. By 2023, coal usage in the EU had fallen by 26%, with an additional 21 GW of coal capacity, representing one-fifth of the bloc’s fleet, slated for closure by 2025.⁵² In addition, the expansion of wind and solar investments have been accompanied by grid modernization, smart grid technologies, and the installation of energy storage systems. Such innovations mitigate the variability of renewables, ensuring grid stability despite the transition. Denmark exemplifies this progress, where aggressive offshore wind expansion has not only stabilized the grid but also underpinned growth in industries reliant on consistent power. Together, these measures demonstrate how targeted policy frameworks and technological adaptation are maintaining a resilient electricity supply while advancing decarbonization goals.

In terms of **electricity capacity diversity**, the picture is more nuanced. Some EU member states, such as Estonia, the Netherlands, and Austria, are facing reliability concerns due to their narrow energy mixes. Estonia relies on shale oil for more than half of its electricity production, making it highly sensitive to changes in EU carbon pricing, although shale-based production is rarely fully employed as Estonia’s interconnectors with Finland EstLink 1 & 2 enable it to import cheaper renewable energy-based electricity.⁵³ However, the power import capacity was significantly reduced in December 2024, after a vessel carrying Russian oil damaged the EstLink 2 interconnector. This caused electricity prices in Estonia to spike and highlighted the vulnerability of energy infrastructure in the Baltic Sea to Russian sabotage.

⁵² Brown, S., and Jones, D., *European electricity review 2024*, Ember, 2024.

⁵³ International Energy Agency, “Replacing oil shale with renewables in the power system can help Estonia achieve its energy and climate ambitions”, 20 November 2023.

The Netherlands, a star performer in the reliability risk segment, remains heavily reliant on gas-fired power plants, which made up 33% of its installed capacity in 2023. After ending domestic gas production due to environmental and security concerns, the country saw household electricity prices rise to the highest levels in the EU. Austria, meanwhile, sources over 50% of its electricity from hydro. While this supports decarbonization efforts, it also exposes the country to severe reliability risks in the case of heat waves and droughts. Finland, Germany, and Denmark lead the EU in capacity diversity, with no single technology exceeding 27% of their installed capacity. This balance mitigates risks from external shocks, such as the “Dunkelflaute”, periods of simultaneous low wind and solar output. While Germany’s grid occasionally faces such events, the severity of the problem is exaggerated as its backup coal and gas plants, coupled with cross-border interconnections, are sufficient to avert blackouts.

A well-integrated European grid remains the most effective safeguard against localized energy crises. Dunkelflaute events rarely coincide across regions⁵⁴, enabling countries to leverage surplus power from neighbors. Central and Eastern Europe holds significant untapped potential to mitigate evening electricity price spikes by expanding onshore and offshore wind generation and developing a modern, interconnected regional power grid. However, progress is hindered by the slow rollout of new wind capacity and high transmission and distribution losses in several member states. In 2023, several countries along the North-South corridor from Estonia to Greece, reported electricity losses exceeding 10% of net production. A key contributor to these inefficiencies is the aging grid infrastructure: the average age of transmission and distribution lines as in many of these countries exceeds 30 years, with some lines in Romania dating back more than half a century.⁵⁵ Unlocking the region’s clean energy potential will require a large-scale investment program focused on modernizing and expanding grid infrastructure. Without such investment, the CEE region risks falling behind in the energy transition and facing prolonged exposure to volatile electricity prices.

To further strengthen the reliability of Europe’s energy systems, the EU should prioritize coordinated investments in **cross-border grid integration, flexible backup capacity, and real-time digital monitoring tools**. Reinforcing the interconnection capacity across member states and deploying smart grid technologies will enhance the system’s ability to absorb variable renewable generation and respond to shocks such as extreme weather events or supply disruptions. These improvements are not only critical for reliability but they also directly support the broader energy trilemma. By reducing curtailment, enabling greater renewable penetration, and stabilizing energy flows, improved reliability measures contribute to sustainability and affordability goals while diminishing geopolitical exposure to imported fuels. In doing so, the EU can build a more cohesive energy union where resilient infrastructure serves as the backbone of both decarbonization and energy security.

⁵⁴ Li, B. et al., “A brief climatology of Dunkelflaute events over and surrounding the North and Baltic Sea areas”, *Energies* 2021, 14(20), 6508.

⁵⁵ European Courts of Auditors, *Making the EU electricity grid fit for net-zero emissions*, Review 01/2025.

Reliability risk may not dominate headlines the way energy prices or supply disruptions do but it defines the long-term viability of the energy transition. A clean energy system that cannot guarantee stable delivery is one that will struggle to earn public trust or attract sustained investment.

Closing the reliability gap in Europe is not just about building more capacity. It's about building smarter systems, integrating flexibility at every level, and ensuring that institutional readiness matches technological ambition. In the end, reliability is the scaffolding of Europe's future energy economy: often invisible, but absolutely essential. The path to a resilient, low-carbon economy hinges on transforming grids from passive networks into dynamic, continent-scale platforms. While challenges like permitting delays and supply chain bottlenecks persist, Europe's progress proves that strategic grid investments are not merely mitigating risks but unlocking new frontiers of industrial innovation and cross-border prosperity.

Sustainability Risks

The sustainability risk pillar evaluates the environmental sustainability of national economies by assessing their carbon intensity, resource efficiency, and progress toward circularity. It captures both climate-related and material-based risks that affect long-term economic resilience and alignment with climate goals. The indicators span energy use and emissions, as well as environmental pressures from consumption and waste. These factors signal the degree to which economies are decoupling growth from environmental degradation. Sustainability risks are also closely intertwined with geopolitical and affordability risks, as higher shares of renewables and more efficient material use tend to reduce exposure to imported fossil fuels and mitigate carbon-related cost pressures.

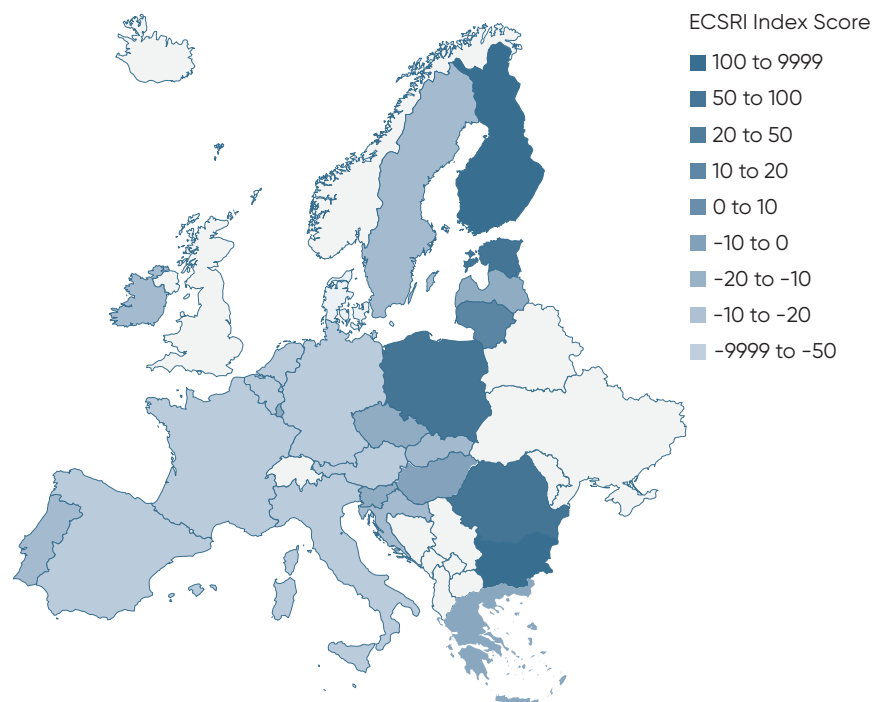
Three years after the EU set itself on a path to accelerate the decarbonization of its economy as a response to the Russian invasion of Ukraine, the EU keeps increasing its level of ambition: the 2040 climate target, endorsed earlier in 2025, calls for a 90% reduction in net greenhouse gas emissions compared to 1990 levels. This is designed as a stepping stone between the current 2030 Fit-for-55 package, which mandates a 55% reduction by 2030, and the legally binding goal of climate neutrality by 2050, set out by the overarching European Green Deal. The Fit-for-55 framework has already driven substantial change, particularly in the power sector, where coal phaseouts, renewable deployment, and higher carbon prices under the ETS have delivered the bulk of Europe's emissions cuts to date.

The data are clear: **Europe is on track to reach above 50% emissions cuts by 2030.**⁵⁶ Yet, Europe's decarbonization story so far is overwhelmingly about cleaning up electricity. But the next stage will be harder. Transport, buildings, and industry, sectors with more diffuse emissions sources, complex technology needs, and entrenched fossil fuel infrastructure, have seen only incremental progress. Decarbonizing them will demand new levels of investment, innovation, and political capital.

⁵⁶ European Commission, "EU closing in on the 2030 climate and energy targets, according to national plans", *Press Release*, Brussels, 28 May 2025.

One of the most **contested tools for tackling these harder-to-abate sectors is ETS-2**, the extension of carbon pricing to road transport and buildings, scheduled to take effect later this decade. In principle, ETS-2 should drive fuel switching, efficiency upgrades, and behavioral change. In practice, it is already deeply unpopular. Critics warn it could spark political backlash by directly raising household fuel bills, especially in countries where energy poverty is already a pressing issue. Several member states have hinted they might resist full implementation, setting up a potential clash between the EU's climate ambitions and the limits of national social acceptance. This tension underscores a broader truth: as the low-hanging fruit of power sector decarbonization is exhausted, the politics of climate policy will get harder, not easier, and managing public consent will be as critical as managing the technology transition.

Figure 19. Sustainability Risks in the EU



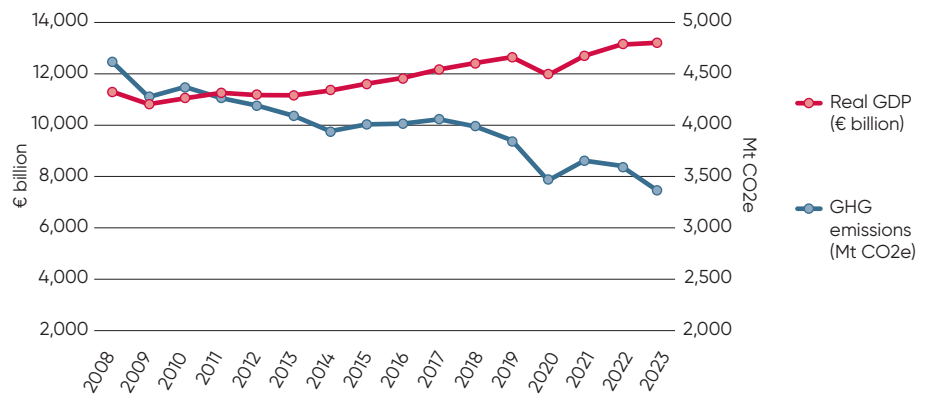
Source: CSD based on ECSRI data.

In a sense, sustainability risks reflect exactly this policy trilemma. Improving energy efficiency not only reduces emissions (sustainability) but also lowers energy bills (affordability) and decreases demand pressures on supply systems (reliability and security). These relationships form positive feedback loops (or trade-offs) depending on the country's energy mix and level of transition. Countries with a high share of renewables already benefit from greater alignment across the different energy policy objectives: their energy is less carbon intensive, less import-dependent, and increasingly affordable, reducing public resistance to further sustainability measures.

In contrast, fossil fuel-dependent economies face more complex trade-offs. For them, transitioning to clean energy involves higher upfront costs, which can heighten short-term affordability concerns and political resistance, especially where economies are rooted in carbon-intensive industries. This divergence is visible in how regions experience the energy transition: while Western and Northern European countries with advanced renewables can focus on synergy-building, Eastern and Southern regions may need stronger financial and structural support to mitigate the sustainability/affordability trade-offs.

Although the EU sustainability risk indicators have significantly improved (net GHG emissions in the EU dropped 34% by 2024 compared to 1990 levels)⁵⁷ over recent years, driven by a comprehensive strategy focused on reducing greenhouse gas emissions, enhancing energy efficiency, and promoting circular economy practices, many EU countries have not been structurally ready to deliver on their ambitious decarbonization goals. Together with total emissions, the EU also reduced its emissions intensity indicator revealing the gradual decoupling between economic growth and the generation of new emissions. Yet, the progress has been uneven as many CEE countries have dragged their feet on the full phaseout of coal, have committed to lock their energy systems in a new gas dependence, and have only sluggishly advanced electrification in the non-energy sectors such as buildings, transportation and industry.

Figure 20. EU Real GDP and GHG Emissions Have Decoupled Over Time



Source: CSD based on ECSRI data.

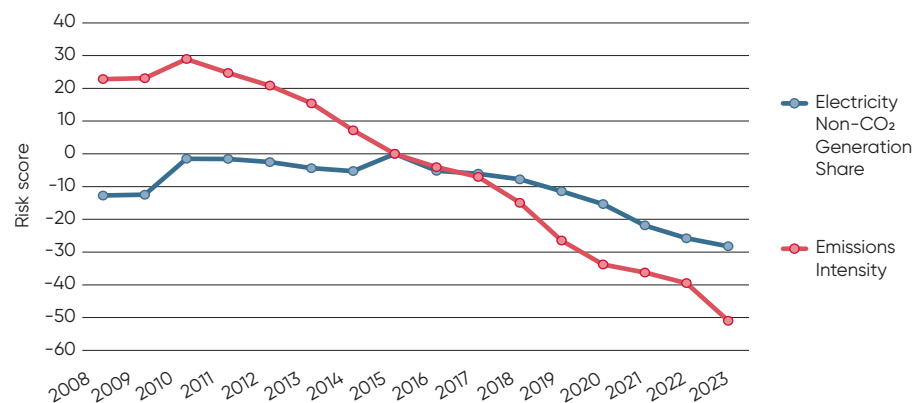
The most important factor contributing to the decline in sustainability risks is **the rising cost of ETS allowances since 2017**. The price reached an annual average of €83 per tonne of carbon dioxide (tCO₂) in 2023, up from €25/tCO₂ in 2020.⁵⁸ In the wake of the energy crisis and Russia’s invasion of Ukraine, the EU has intensified its efforts to accelerate the clean energy

⁵⁷ European Environment Agency, “Total net greenhouse gas emission trends and projections in Europe”, 31 October 2024.

⁵⁸ European Environment Agency, “Use of auctioning revenues generated under the EU Emissions Trading System”, 19 December 2024.

transition, particularly through the REPowerEU initiative⁵⁹. This plan has led to a faster expansion of clean energy despite the broader regulatory, financing and implementation challenges linked to new low-carbon projects.

Figure 21. A Higher Share of Renewables Has Lowered Emissions in Recent Years



Source: CSD based on ECSRI data.

CEE countries experience higher sustainability risks due to slower transitions away from fossil fuels and persistent reliance on carbon-intensive industries. Bulgaria exemplifies the sustainability risks faced by many Central and Eastern European countries, where the transition away from fossil fuels remains uneven and carbon-intensive industries continue to dominate.

- Despite achieving a 60% reduction in emissions intensity between 2008 and 2023, **Bulgaria** still ranks as the second-most emissions-intensive economy in the EU.⁶⁰ Its energy intensity remains the highest in the bloc, a reflection of longstanding inefficiencies across residential, industrial, and service sectors. Although rising carbon prices and the addition of over 2,300 MW of solar capacity in 2023 and 2024 contributed to a decline in coal plant utilization, lignite plants continue to make up around 58% of total CO₂ emissions from fuel combustion. Meanwhile, progress on the circular economy has been sluggish—waste per capita remains above the EU average, and the circular material use rate is still among the lowest in the Union.⁶¹

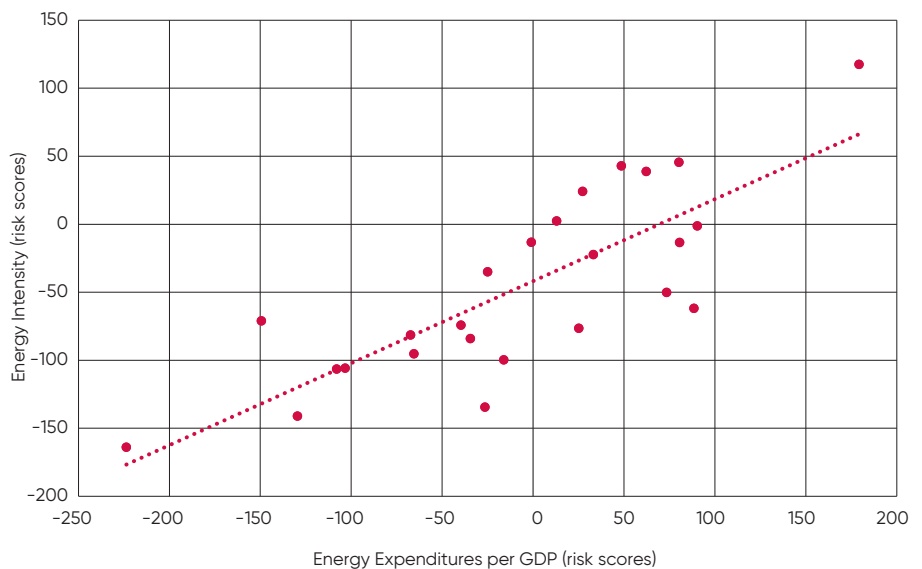
⁵⁹ EU-wide efforts such as the Renovation Wave, part of the Green Deal, aim to renovate 35 million buildings by 2030, showcasing how coordinated investments in efficiency can simultaneously drive decarbonization, energy savings, and green job creation. Similarly, the expansion of renewable energy plays a vital role in advancing all aspects of the trilemma. Clean energy technologies—such as wind and solar—lower emissions, enhance security by reducing dependence on fossil fuel imports, and gradually improve affordability as capital costs are amortized. Initiatives like the Renewable Energy Directive and Fit for 55 have set ambitious targets for renewables, encouraging long-term shifts away from volatile fuel markets. European Commission, [Renovation Wave](#), Directorate-General for Energy (n.d.).

⁶⁰ Think Tank, [“Bulgaria’s climate action strategy”](#), *Briefing*, European Parliament, 19 December 2024.

⁶¹ European Environment Agency, [Bulgaria 2024 circular economy country profile](#), 3 December 2024.

- **Poland**, despite recent announcements of coal decommissioning, still generates over 65% of its electricity from coal. The country has made progress in offshore wind planning, but slow permitting, weak grid readiness, and political resistance to carbon pricing reforms have delayed the implementation of broader energy transition policies. Its power sector remains among the highest-emitting in Europe, and heat and transport electrification lags far behind.
- **Czechia, Romania, Hungary and Slovakia** face high emissions intensity due to a combination of legacy industrial bases, inefficient district heating systems, and limited domestic renewable energy potential. In both cases, natural gas has also become the default decarbonization pathway but without sufficient diversification, this simply replaces one fossil dependency with another.

Figure 22. Less Energy-intensive Countries Had Lower Energy Expenditures per GDP in 2023



Source: CSD based on ECSRI data.

Energy intensity and CO₂ emissions intensity have both significantly decreased, reflecting improvements in energy efficiency and a decisive shift toward the use of renewable energy sources. The emission intensity of electricity generation, in particular, has seen a 35% reduction over the course of the past decade.⁶² Countries heavily investing in renewables, such as **Germany, Spain, Portugal, Denmark, Belgium and Netherlands**, have considerably shrunk their reliance on carbon-intensive energy sources.

- Germany's substantial renewable capacity expansion, especially in wind energy, which represents 27.5% of its electricity generation mix, exempli-

⁶² European Environment Agency, [Greenhouse gas emission intensity of electricity generation in Europe](#), 27 June 2024.

fies this successful transition, despite challenges related to grid integration and local acceptance.⁶³

- **France** stands out across the EU with the lowest electricity non-CO₂ generation share risk (-188.7), a reflection of its heavy reliance on nuclear energy, which consistently provides over 60% of the country's electricity needs.⁶⁴ This low-carbon baseload not only minimizes volatility in power generation but also significantly reduces France's emissions footprint, contributing to its strong emissions intensity score (-106.6).
- **Austria** presents a different but equally effective model. With approximately 80% of its electricity coming from renewable sources, primarily hydropower, Austria achieves similarly low emissions intensity.⁶⁵ This renewable dominance explains its strong performance on non-CO₂ generation risk (-149.2) and positions it as an energy transition leader.

Governance Bottlenecks

Several common challenges in the design and implementation of energy transition governance in Europe remain. The **cost competitiveness of decarbonization policies** remains a key challenge, especially given the volatility of energy markets and the pressure on renewable energy equipment supply chains. While falling costs of solar and wind energy make them more attractive, their high upfront costs, coupled with rising financing costs, have slowed the transition process. Investments in energy storage, grid modernization, and hydrogen infrastructure require additional financial commitments that may be difficult to secure without strong policy incentives.

Social acceptance remains another major barrier to decarbonization. While public support for renewables remains strong, specific projects often face local opposition due to land use conflicts, biodiversity concerns, and visual impacts. The energy crisis has exacerbated public resistance in some regions, as climate-skeptic narratives have convinced the public that renewables cause high energy prices. Perception of renewables as unreliable has also been exploited by different fossil fuel advocates, leading to weaker political will to implement targeted policy measures that can overcome some of the bottlenecks before the transition. For instance, following the April 2025 Iberian Peninsula blackout, right-wing political factions swiftly attributed the outage to the nation's reliance on renewable energy sources, despite ongoing investigations indicating that grid management issues and limited interconnections were the primary causes (see Box 5).

Regulatory bottlenecks have also continued to slow down renewable energy deployment. While REPowerEU aims to simplify the permitting processes, many member states still struggle with lengthy approval timelines, fragmented governance, and inadequate grid infrastructure. The absence of

⁶³ International Energy Agency, [Germany](#) (n.d.).

⁶⁴ International Energy Agency, [France](#) (n.d.).

⁶⁵ European Commission, [Austria – Final updated NECP 2021 – 2030](#), Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology, Vienna, 2024.

one-stop-shops for renewable project approvals leads to delays of 5-7 years for wind power parks, significantly hindering the speed of the transition.⁶⁶ Additionally, energy market liberalization remains incomplete in some member states, further complicating investment in renewables. In many cases, support mechanisms for renewables exist guided by the corresponding EU Directives, but their implementation is not well adapted to each country.

A critical emerging challenge for Europe's energy transition is the growing interconnection between sustainability risks and resource security risks. As Europe reduces dependence on fossil fuels, it will need substantial imports of critical metals and minerals, such as lithium, cobalt, nickel, and rare earth elements, which are essential for batteries, solar panels, wind turbines, and electric vehicles. Many of these resources are concentrated in a few supplier countries, raising concerns about the national security vulnerabilities related to the excessive dependence on China. In 2023, 94% of EU imports of rare earth elements came from China, Malaysia and Russia combined.⁶⁷

Ensuring a **stable and resilient supply of critical raw materials** is now a foundational requirement for the EU's clean energy transition. Supply chain disruptions or export restrictions caused by geopolitical tensions, market manipulation, or global demand surges can delay renewable energy deployment, increase costs for solar and battery technologies, and stall industrial decarbonization plans. The EU's high dependency on a small number of external suppliers for CRMs like rare earths, lithium, and cobalt puts its energy security and technological sovereignty at risk. As demand accelerates, securing access to these materials is no longer just an economic priority but a strategic imperative for meeting Green Deal targets, sustaining innovation, and maintaining competitiveness in clean tech manufacturing.

Material Footprint Reduction

Effective waste management and **circular economy** practices are increasingly recognized as strategic tools for reducing sustainability risks and enhancing long-term resource security in Europe. Beyond their environmental impact, these measures directly support economic resilience by lowering raw material dependence and mitigating exposure to global supply shocks. Across the EU, improved recycling rates and policies to curb single-use materials have contributed to a decline in per capita waste and a modest rise in circular material use. Notably, while the EU's material footprint remained stable between 2010 and 2022, it declined by 4.5% in 2023, suggesting early signs of structural change.

However, challenges remain: raw material extraction stood at 14.1 tonnes per capita in 2023, a level that exceeds sustainable thresholds and remains well above the global average.⁶⁸ This underscores the urgency of accelerating circular economy initiatives, not only to meet climate and sustainability goals,

⁶⁶ Piotrowski, M., and Gislén, M., "How permitting processes are hampering Europe's energy transition", *World Economic Forum*, 17 September 2024.

⁶⁷ Eurostat, *International trade in critical raw materials*, Statistics Explained, November 2024.

⁶⁸ European Environment Agency, *Europe's material footprint*, 13 December 2024.

but also to reduce the EU’s vulnerability to raw material scarcity, especially as demand for critical inputs surges in the clean energy transition. **Scaling up reuse, recycling, and sustainable product design** will be essential to decouple economic growth from resource consumption and move Europe closer to a truly regenerative economy.

Europe’s material footprint is largely driven by heightened demand for critical raw materials essential for clean energy technologies.⁶⁹ These materials are indispensable for batteries, wind turbines, solar panels, and electric vehicles, resulting in substantial extraction pressures and environmental impacts in supplier regions. Additionally, the material footprint continues to be exacerbated by limited recycling infrastructure, consumer behaviors favoring single-use products, and industrial processes still transitioning to circular practices.⁷⁰ Despite these challenges, recent EU initiatives, including the Sustainable Product Initiative, Right to Repair policies, and the Circular Economy Action Plan, are beginning to reduce primary material consumption by extending product lifespans, enhancing recycling efficiency, and fostering secondary raw material markets.

In addition to metals and minerals, Europe will also need to scale up imports of low-carbon equipment, including solar panels, wind turbines, and electrolyzers for hydrogen production. This shift underscores the need for strategic industrial policies to develop domestic manufacturing capabilities, reduce supply chain risks, and ensure that the decarbonization process does not create new resource dependencies that could undermine long-term sustainability and geopolitical risks.

Figure 23. The Security of Supply of Raw Materials and Renewable Energy Equipment and Material Consumption



Source: CSD based on ECSRI data.

⁶⁹ European Environment Agency, [Europe’s material footprint](#), 13 December 2024.

⁷⁰ Sakao, T. et al., “Implementing circular economy activities in manufacturing for environmental sustainability”, *CIRP Annals*, Vol. 73, Issue 2, 2024, pp. 457-481.

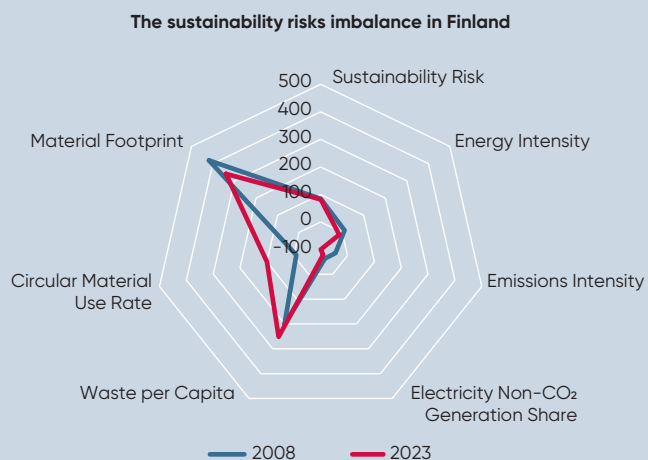
Box 6. The Sustainability Conundrum: The Case of Finland

Finland’s case illustrates the complexity of sustainability, which not only includes energy sector decarbonization, but also material efficiency, circularity, and long-term resource resilience. While Finland performs well on several energy-related indicators of sustainability, including energy intensity, emissions intensity, and the share of electricity generated without CO₂ emissions, it also has the highest material footprint in the EU, the third-lowest circular material use rate, and produces the most waste per capita.

These outcomes are driven in part by Finland’s forest and paper industries, which, despite being energy-efficient and powered largely by bioenergy, are highly material-intensive. Large volumes of logging, paper production, and bio-based exports significantly inflate the country’s overall material footprint.

Additionally, Finland’s active mining and metals sector (notably nickel, copper, and cobalt) plays a key role in supporting the EU’s green technology supply chains but contributes heavily to raw material extraction and industrial waste. A high standard of living further increases consumption of goods, packaging, and disposable products, pushing waste generation even higher.

Finland’s geographic and climatic conditions, harsh winters and long distances between population centers, also elevate energy and material demands for heating, insulation, transportation, and remote infrastructure development. While household recycling rates are relatively good, industrial sectors like construction remain major sources of waste, with limited integration of recycled materials. Demolition waste often ends up in landfills or incinerators, and the widespread use of virgin biomass rarely feeds back into circular loops.



Source: CSD based on ECSRI data.

The Netherlands and Italy stand out in Europe for their strong performance in circular economy practices, particularly in their circular material use rates, reflecting the success of their robust recycling systems and industrial symbiosis models. The **Netherlands** has implemented forward-leaning “waste-to-resource” policies that incentivize reuse and closed-loop manufacturing,⁷¹ while **Italy’s** longstanding recycling culture—reinforced by national packaging laws and local waste separation programs—has driven similarly high circularity rates.

By contrast, Spain lags behind, with one of the lowest circular material use rates in the EU, largely due to fragmented regional waste systems and limited investment in recycling infrastructure.⁷² However, Spain’s service- and tourism-oriented economy requires relatively fewer raw materials, while the Netherlands benefits from high-tech, export-oriented manufacturing and widespread adoption of circular practices.⁷³

Decarbonizing energy markets will deliver a blow to the Kremlin’s ambition to increase its economic and political influence in Europe. Around 15% of Russia’s oil and gas budget revenues come from the sale of gas⁷⁴. Choosing to decarbonize the energy system while requiring large investments in renewable energy, storage technologies and smart grids, could also solve the supply security conundrum linked to the exit of fossil fuel-based baseload capacity. High electricity prices are incentivizing investments in previously prohibitively expensive technologies such as floating offshore wind, power storage, and green hydrogen. As EU member states increase renewable energy and sustainability initiatives, geopolitical and affordability risks will also decrease, as renewable energy will reduce reliance on fossil fuel suppliers and decrease costs due to more domestic production and increased energy efficiency.

Reducing sustainability risks will be essential to securing Europe’s long-term climate, economic, and resource goals. Policymakers must continue to support structural shifts that reduce energy and material intensity while promoting circularity across industrial sectors. This includes expanding the use of recycled materials, reducing reliance on virgin biomass and raw materials, and continuing the green transition to renewable energies.

⁷¹ Oorschot, A., and Ratingen, B., *Circular Economy: DSGC companies on their journey of implementing circular business models*, Dutch Sustainable Growth Coalition.

⁷² Fundación BBVA, *Evolución de la economía circular en el siglo XXI* [The evolution of the circular economy in the 21st century], *Esenciales* 01/2024.

⁷³ Wit, M., Haigh, L., and Daniels, C., *The Circularity GAP Report – the Netherlands*, Circle Economy, 2020.

⁷⁴ Yermakov, V., *Fiscal Flex: Russia’s oil and gas revenues in 2024*, Oxford Institute for Energy Studies, 2025.

Enhancing material efficiency and minimizing environmental impacts across the value chain will help decouple economic growth from resource consumption. In turn, these measures **lower exposure to volatile resource markets and environmental degradation**, reinforcing both economic resilience and climate goals. As the EU deepens its sustainability agenda, it will not only reduce emissions and waste but also drive down geopolitical and affordability risks by cutting dependence on emissions-intensive imports and carbon-priced fuels.

Europe's declining sustainability risks reflect significant progress toward a robust, resilient, and sustainable economic future. By capitalizing on the intersection of sustainability, economic growth, and energy security, Europe is poised to reinforce its global competitiveness and secure a sustainable economic and environmental legacy.

WHAT'S NEXT

The data from the ECSRI paints a clear picture: Europe's energy transition is at a critical inflection point. While the past three years have demonstrated the EU's capacity to respond to crisis, particularly in reducing dependency on Russian fossil fuels: the path forward is structurally more complex. It is no longer a question of emergency substitution or marginal policy upgrades. The EU must now engage in a comprehensive re-engineering of its energy system, one that can reconcile the imperatives of competitiveness, reliability, affordability, and sustainability.

The transition is not only about achieving carbon neutrality by mid-century. It is about **preventing energy and climate security risks** from crystallizing into **economic dislocation, social backlash, or geopolitical fragmentation**. In short, energy is now both the arena and the instrument of Europe's strategic autonomy. And this autonomy will not be won by political declarations alone, but by building credible systems, functional institutions, and shared prosperity across all regions.

The following five policy directions offer a roadmap to reduce risk, strengthen cohesion, and unlock the transformative potential of Europe's energy transition.

1. Rebuilding Europe's Energy Competitiveness

Restoring affordability and long-term competitiveness must be at the heart of Europe's energy strategy. While short-term interventions have shielded consumers from the worst effects of the 2021–2023 price spikes, they have not addressed the structural factors behind Europe's high energy costs: inflexible market design, grid bottlenecks, and underdeveloped flexibility markets.

To shift from crisis management to strategic competitiveness, the EU and its member states must accelerate the deployment of long-term price signals, such as contracts for difference (CfDs) and power purchase agreements (PPAs), that reward clean, firm, and flexible generation. At the same time, energy-intensive industries need targeted support mechanisms to navigate the cost of carbon pricing, especially where decarbonization alternatives remain technically or commercially immature. Carbon contracts for difference (CCfDs), green industrial clusters, and access to competitively priced clean electricity are no longer industrial policy luxuries but the preconditions for keeping strategic sectors in Europe.

Europe must also reframe its affordability agenda around fairness and access. Market signals must be balanced with targeted, means-tested support for vulnerable households, and not with politically expedient but economically distortive subsidies for fossil fuels. Without a strategic reset, Europe risks losing both its climate credibility and its industrial base.

2. Strengthening Grid Infrastructure for Systemic Resilience

The reliability of the European energy system is increasingly defined not by how much capacity is available, but by how well that capacity is integrated and managed. The rapid growth of variable renewable energy has outpaced the capacity of transmission and distribution networks to accommodate it, particularly in Southern Europe.

If Europe is to build a modern, renewables-based power system, it must invest in the infrastructure and digital capabilities that make that system stable. This includes expanding physical interconnections, upgrading ageing grid assets, and deploying smart grid technologies that allow for real-time system balancing. Equally important is investment in flexibility: storage, demand response, and grid-forming capabilities can stabilize the system under stress.

To both boost the resilience of the energy system and strengthen the competitiveness of its economy, Europe should accelerate innovation in cutting-edge low-carbon technologies by aligning EU research and innovation funding with deployment incentives for hydrogen, advanced storage systems, carbon capture and utilization, small modular reactors, and next-generation renewable technologies. Innovation must be embedded in industrial strategy so that Europe not only adopts but also develops and exports the technologies needed for deep decarbonization.

Systemic resilience is not simply a technical challenge, it is a governance one. Regulatory frameworks must reward flexibility, not penalize it. Infrastructure planning must be anticipatory, not reactive. And investment flows must prioritize grid upgrades with the same urgency as renewable deployment. Without this rebalancing, the risks of curtailment, blackout, and public backlash will only increase, undermining the energy transition's legitimacy.

3. Aligning Fossil Phaseouts with Institutional Readiness

The credibility of Europe's climate policy rests on its ability to move from ambition to execution, particularly in the structural phaseout of fossil fuels. Yet, in many countries, transition planning remains fragmented, underfunded, and politically fragile. This is especially true for coal phaseouts, where timelines often lack adequate economic support for affected regions or technical strategies for system replacement.

To close the gap between target and delivery, the EU must help member states develop integrated fossil exit strategies, which are coordinated across the electricity, heating, and transport sectors. These strategies should include clear timelines for decommissioning, incentives for clean alternatives, and a binding link to Just Transition financing and industrial repurposing. The electrification of heating and transport, in particular, needs to move beyond pilot programs toward structural replacement of legacy systems.

But phaseouts also require capable institutions. Many high-risk countries in the ECSRI suffer from weak permitting, inefficient public utilities, or fragmented regulatory oversight. Transition funding should be conditional on governance reforms that improve institutional effectiveness. Only with stronger delivery capacity can phaseout plans become credible pathways, not paper commitments.

4. Governing the Transition: A New Pact for Institutional Resilience

The energy transition is ultimately a governance test. Without strong institutions, even the best-designed policies will falter in implementation. The ECSRI reveals a stark correlation between sustainability risks and institutional bottlenecks: countries with the highest emissions intensity and slowest electrification also suffer from under-resourced regulators, sluggish permitting systems, and limited municipal capacity.

To overcome these structural weaknesses, the EU should expand technical assistance and administrative capacity-building programs, particularly in countries with the highest risk profiles. National Energy and Climate Plans should include institutional performance metrics and risk-based planning tools that track delivery gaps over time.

A broader EU-level governance reform is also needed. A fragmented regulatory architecture, which is split between energy, environment, competition, and cohesion policy, cannot meet the scale of the transformation required. A coherent transition governance framework, supported by risk-monitoring instruments such as the ECSRI, would help align planning, funding, and implementation around a common objective: delivering a just, secure, and sustainable energy future.

5. Anchoring Strategic Autonomy in Secure and Sustainable Supply Chains

The success of the European Green Deal will depend not only on internal reforms but also on the EU's ability to manage external dependencies. Europe has reduced its reliance on Russian energy, but new vulnerabilities are emerging in the form of critical raw material and renewable energy equipment import dependence.

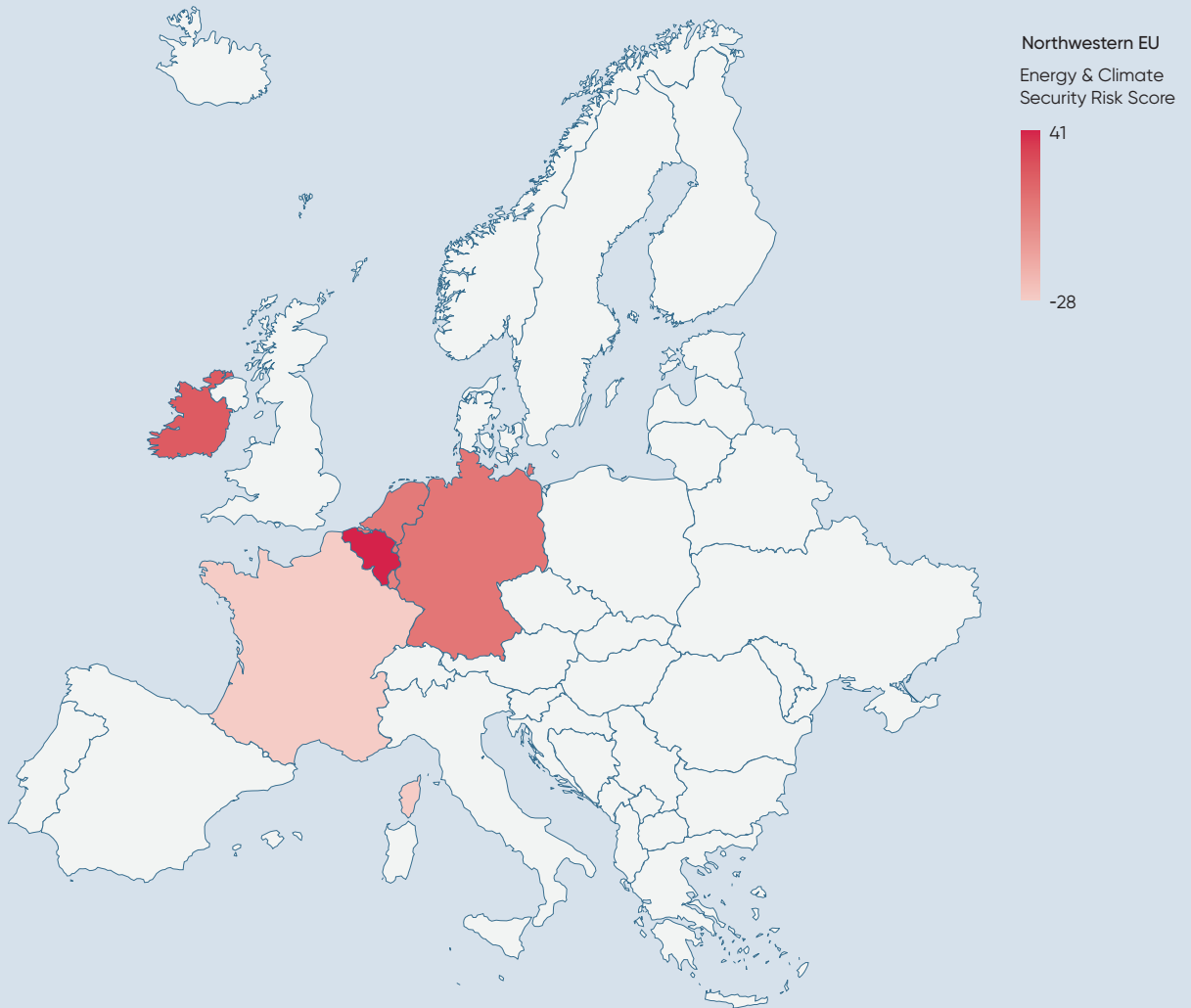
Strategic autonomy must therefore be grounded in a proactive industrial and trade policy that combines diversification, circularity, and resilience. This includes investing in domestic extraction and processing of critical raw materials, building strategic partnerships with the EU's allies for secure supply chains, and accelerating the development of closed-loop industrial ecosystems for clean technologies.

At the same time, Europe must leverage its trade and investment tools to align external partnerships with its climate and security objectives. Instruments such as the EU Critical Raw Materials Act, the Carbon Border Adjustment Mechanism, and the Global Gateway should be operationalized not only as climate diplomacy tools, but as **groeconomic instruments for resilience**.

In the new energy order, security is not just about gas storage or military alliances—it is about **who controls the building blocks of decarbonization**. Europe's strategic autonomy will be determined by its ability to access, process, and govern those building blocks on its own terms.

ANNEX 1. REGIONAL AND COUNTRY PROFILES

NORTHWESTERN EUROPE



Countries Included:

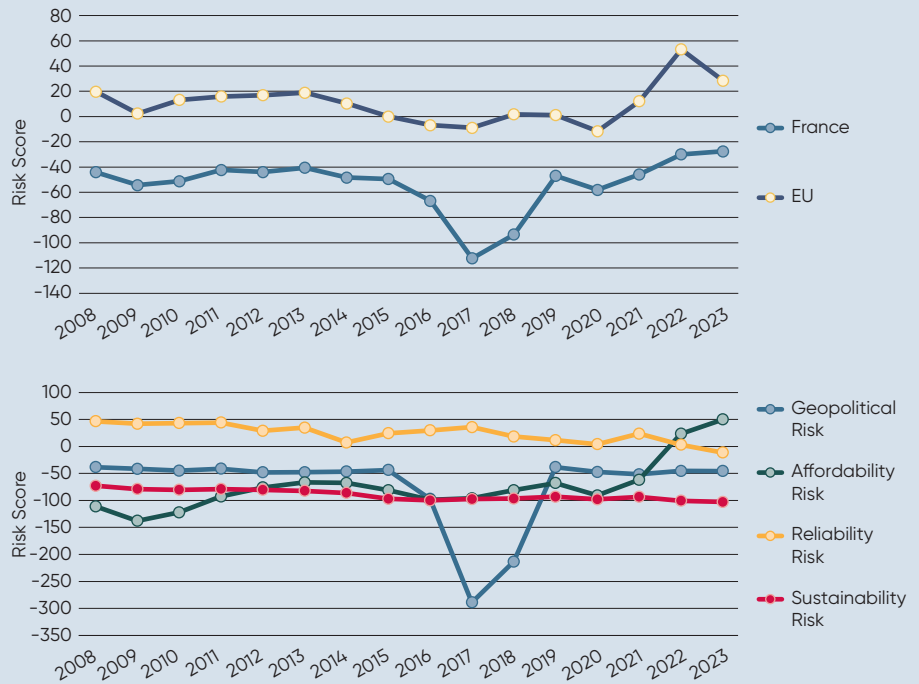
- **Belgium**
- **France**
- **Netherlands**
- **Germany**
- **Ireland**
- **Luxembourg**

Northwestern EU countries have performed very well on most energy and climate security risk indicators. These nations benefit from high GDP per capita, diversified energy systems, and well-developed infrastructure, which help reduce affordability and reliability risks. Their commitment to renewable energy and energy efficiency further strengthens their resilience. However, emerging dependencies such as on imported critical raw materials and, in the Netherlands' case, on gas imports following the Groningen field shutdown signal new challenges on the horizon.



FRANCE

Energy Security Risk Score Summary	
2023 Energy Security Risk Score	-28
Geopolitical Risk	-46
Affordability Risk	50
Reliability Risk	-11
Sustainability Risk	-103
ECSRI Score in 2015	-49
Overall Rank	1



France stands out as the top performer in the ECSRI, demonstrating its success in navigating the energy trilemma of ensuring secure, affordable, and sustainable energy. Central to this strong performance is its heavy reliance on nuclear power, which accounted for 68% of the country’s electricity generation in 2021.⁷⁵ As a domestically sourced and low-carbon energy option, nuclear energy has reduced both France’s dependency on fossil fuel imports and its exposure to geopolitical risks. This strategic focus has helped keep energy prices below the EU average, supported by a balanced mix of nuclear, renewables, and fossil fuels, as 90% of France’s electricity is already decarbonized.⁷⁶

France also holds the lowest electricity non-CO₂ generation share risk score in the EU (-188.7), highlighting the dominance of nuclear power in its generation mix. This has also contributed to its exceptionally low emissions intensity score (-106.6), placing it alongside Sweden, Luxembourg, and Ireland in achieving the lowest emissions intensity in 2023. France’s domestic mining and refining capacity for metals and minerals further strengthens its raw material security, although its production remains modest compared to the biggest suppliers to the EU such as China.

France’s sustainability efforts are reinforced through ambitious national targets and supportive policy instruments. The government has committed to achieving carbon neutrality by 2050 and a 42.5% share of renewable energy by 2030, in line with broader EU goals. Policy tools such as MaPrimeRénov, providing grants for household energy retrofits, have improved energy efficiency while helping reduce emissions and energy costs for consumers.

Beyond its national priorities, France plays a pivotal role in supporting Europe’s overall energy security. Its large nuclear fleet enables France to export surplus power to neighboring countries including Germany, Belgium, and Italy. These exports are particularly critical during periods when wind and solar output in Northern Europe falls short, helping stabilize the regional grid and reduce reliance on fossil fuel backup generation. France has also expanded its LNG regasification capacity at key terminals in Dunkirk and Fos-sur-Mer, reinforcing its position as a redistribution gas hub for land-locked countries in Central Europe.

However, the resilience of this system was tested in 2022, when persistent droughts, extreme heat, and ongoing reactor maintenance significantly reduced

⁷⁵ World Nuclear Association, *Nuclear power in France*, Updated: 14 July 2025.

⁷⁶ Nguyen, P.-V., *France’s Energy Future: What Policy for the new five-year term?*, Policy Paper No. 280, Jacques Delors Institute, July 2022.

nuclear output. Limited availability of cooling water forced several reactors offline, temporarily shifting France from an electricity exporter to an importer. This contributed to price spikes and increased gas consumption across Europe, underscoring both the continent's dependence on France's nuclear capacity and the importance of building climate-resilient energy systems. France was equally impacted, highlighting its continued exposure to fossil fuel

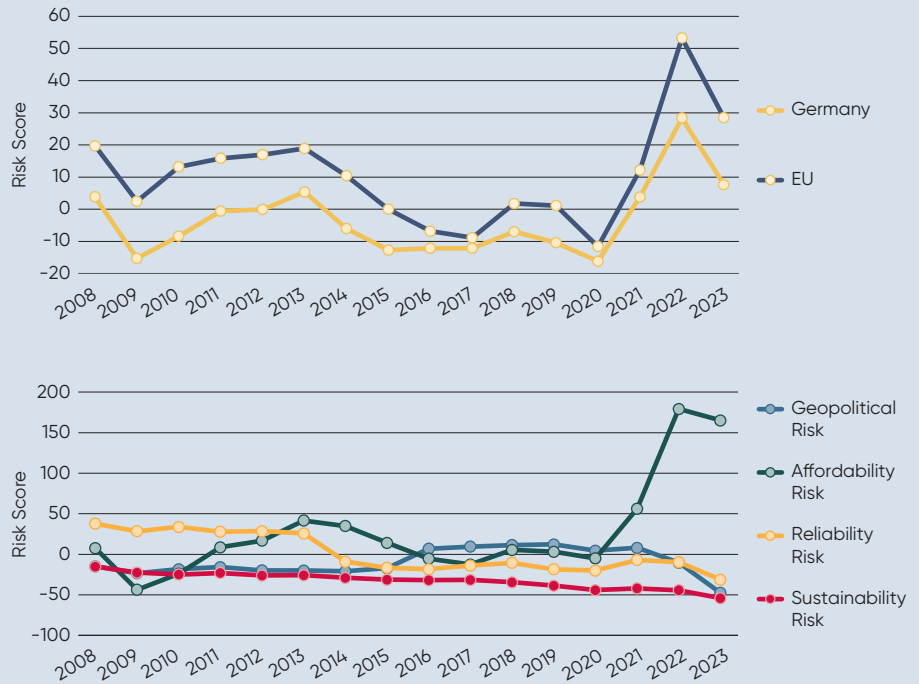
price volatility and need to fully decarbonize in line with national goals.⁷⁷ France has also faced persistent maintenance problems at many of its nuclear facilities contributing to the volatility of their generation profile leading to market instability across the continent. Despite these challenges, France remains a strong model for achieving a secure, affordable, and low-emissions energy future, leveraging its nuclear backbone, efficient policies, and regional influence.

⁷⁷ Ledez, M., and Hainaut, H., *Landscape of climate finance in France – 2022 edition*, I4CE – Institute for Climate Economics, 2023.



GERMANY

Energy Security Risk Score Summary	
2023 Energy Security Risk Score	8
Geopolitical Risk	-48
Affordability Risk	165
Reliability Risk	-31
Sustainability Risk	-54
ECSRI Score in 2015	-13
Overall Rank	11



Germany occupies a central role in Europe’s energy and climate security architecture, acting as both a major energy importer and a vital clean energy producer. Historically, Germany’s dependence on Russian fossil fuels tied much of Central Europe into similar vulnerabilities. However, following Russia’s weaponization of energy supplies in 2022, Germany underwent a rapid and profound energy diversification. Russian gas and oil imports fell close to zero by 2023, replaced by Norwegian pipeline gas and LNG. The German state also took over the management of the Rosneft-owned Schwedt refinery in Eastern Germany and of Gazprom Germania, operating three of the country’s largest storage facilities. Although some residual exposure to Russian LNG (between 10 and 15% of total imports) remains through third countries like Belgium, France and the Netherlands, Germany’s decoupling from Russia marks one of the most decisive shifts in Europe’s recent energy history.⁷⁸

Germany’s evolving energy system has had wide-reaching effects beyond its borders. As Germany diversified and built out its LNG import infrastructure, countries like Austria, Czechia, and Slovakia have increasingly relied on German routes for gas and electricity imports. Austria, for example, mitigated

its own Russian gas exposure by securing alternative supplies via Germany and Italy.

Berlin’s strategic shift came at a significant economic cost. Energy affordability risks escalated sharply as Germany scrambled to replace cheap Russian supplies with more expensive alternatives from global markets. Electricity and gas prices surged, straining households and industries alike. The affordability crisis highlights the vulnerability created when a major low-cost supplier is lost without sufficient domestic substitutes immediately available. Germany’s decision to phase out coal and nuclear generation at the same time further tightened the power supply, exacerbating cost pressures even as the country expanded renewable investment.

On the back of the *Energiewende*, since 2014, emissions in Germany’s energy sector have dropped by ~40%.⁷⁹ Renewable energy, particularly wind power, has become increasingly vital not only for Germany’s own system resilience but for stabilizing electricity prices across Central Europe. When German wind output is strong, it helps suppress wholesale electricity prices and reduces regional emissions. Conversely, when wind generation is low, neighboring countries experience higher prices and greater reliance on fossil

⁷⁸ Pepe, J. M., *Energie zwischen Markt und Geopolitik: Der Fall LNG. Herausforderungen für die EU und Deutschland seit Russlands Krieg in der Ukraine*, Stiftung Wissenschaft und Politik, SWP-Studie 2025/S 04, 14 March 2025.

⁷⁹ Nesselhauf, L. et al., *Climate-neutral Germany: From target-setting to implementation*, Agora Think Tanks, 2024.

fuels. Continued investment in grid interconnections, and storage systems has further reinforced Germany's ability to manage variability and supply shocks.

Germany's success or failure in maintaining stable, affordable, and clean energy will shape not only its own economy but also Europe's broader ability to achieve energy security and climate goals.⁸⁰ To avoid a backlash against the transition process, which is blamed for the rising energy prices, Germany would have to accelerate

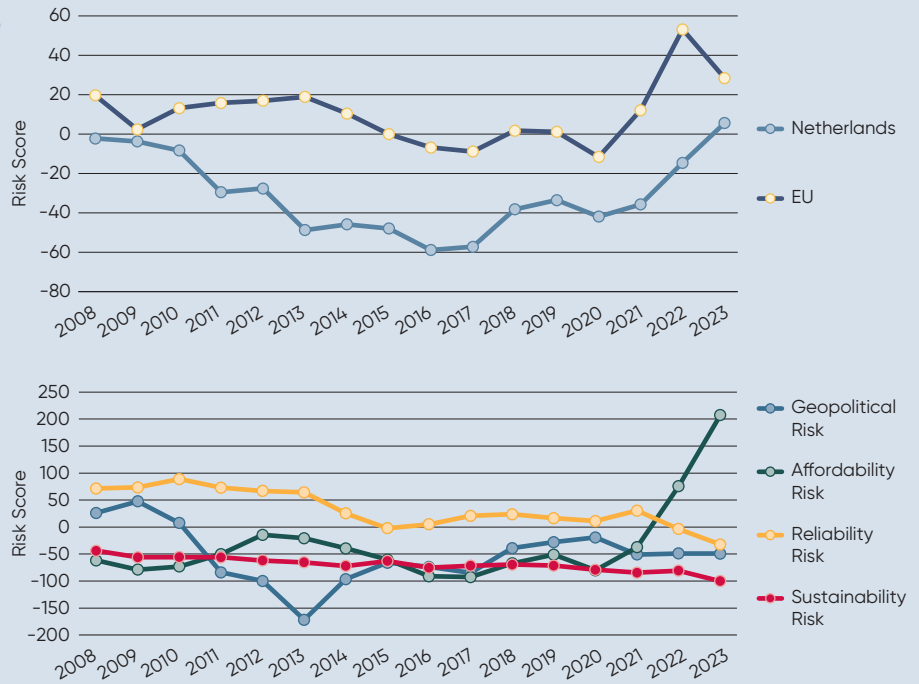
investments in battery storage facilities to balance the electricity market and avoid a lock-in in new gas-based power generation units. There is an urgent need to streamline the disjointed internal power transmission system and strengthen the governance of the energy sector in order to speed up low-carbon investments. However unpopular and costly it may be, Berlin may need to also restart part of its nuclear fleet that will provide a stable bridge to a fully decarbonized power system.

⁸⁰ Bosch, T., "Germany's Climate Foreign Policy Strategy", *Heinrich Boell Foundation*, 4 November 2024.



NETHERLANDS

Energy Security Risk Score Summary	
2023 Energy Security Risk Score	6
Geopolitical Risk	-49
Affordability Risk	207
Reliability Risk	-32
Sustainability Risk	-100
ECSRI Score in 2015	-48
Overall Rank	9



The Netherlands occupies a strategic position in Europe’s energy system, serving both as a critical gateway for energy imports and as a country navigating the complexities of its own energy transition. While its infrastructure and geographic advantages have strengthened its role as Europe’s biggest natural gas hub, the country continues to face persistent structural challenges that affect its long-term energy security, affordability, and sustainability.⁸¹

A key driver of the Netherlands’ energy transition policy has been the decline of domestic natural gas production, following the planned phaseout of Europe’s largest gas field, Groningen, due to seismic risks. Groningen’s closure has forced a rapid shift toward increased LNG imports not only in the Netherlands but all across Northwestern Europe. To manage this shift, the Netherlands has expanded its LNG import and regasification capacity, bolstering regional supply security and enabling larger re-exports to neighboring countries. However, the growing reliance on imported gas has also exposed the Netherlands to volatile global markets and increased its vulnerability to geopolitical risks, particularly in the short term.

Affordability pressures have intensified during the 2021-2023 energy crisis. While government interventions have partially cushioned the impact, households and businesses continue to face elevated energy costs. Unlike countries with more extensive renewable or nuclear capacity, the Netherlands has found it harder to shield end-users from price fluctuations, highlighting a critical gap in its energy resilience.

On the sustainability front, the Netherlands has made substantial policy commitments and investments in renewable energy, particularly by doubling down on offshore wind and solar. Yet fossil fuels still account for a large share of the country’s energy consumption, especially in the industrial, agriculture (on the back of huge subsidies for the gas use) and transport sectors. Progress has accelerated in recent years, with new targets and infrastructure buildouts, but earlier delays in implementation have made the transition more compressed and urgent. Moreover, spatial constraints, grid access bottlenecks and legal battles over environmental and nitrogen regulations have slowed the rollout of clean energy infrastructure.

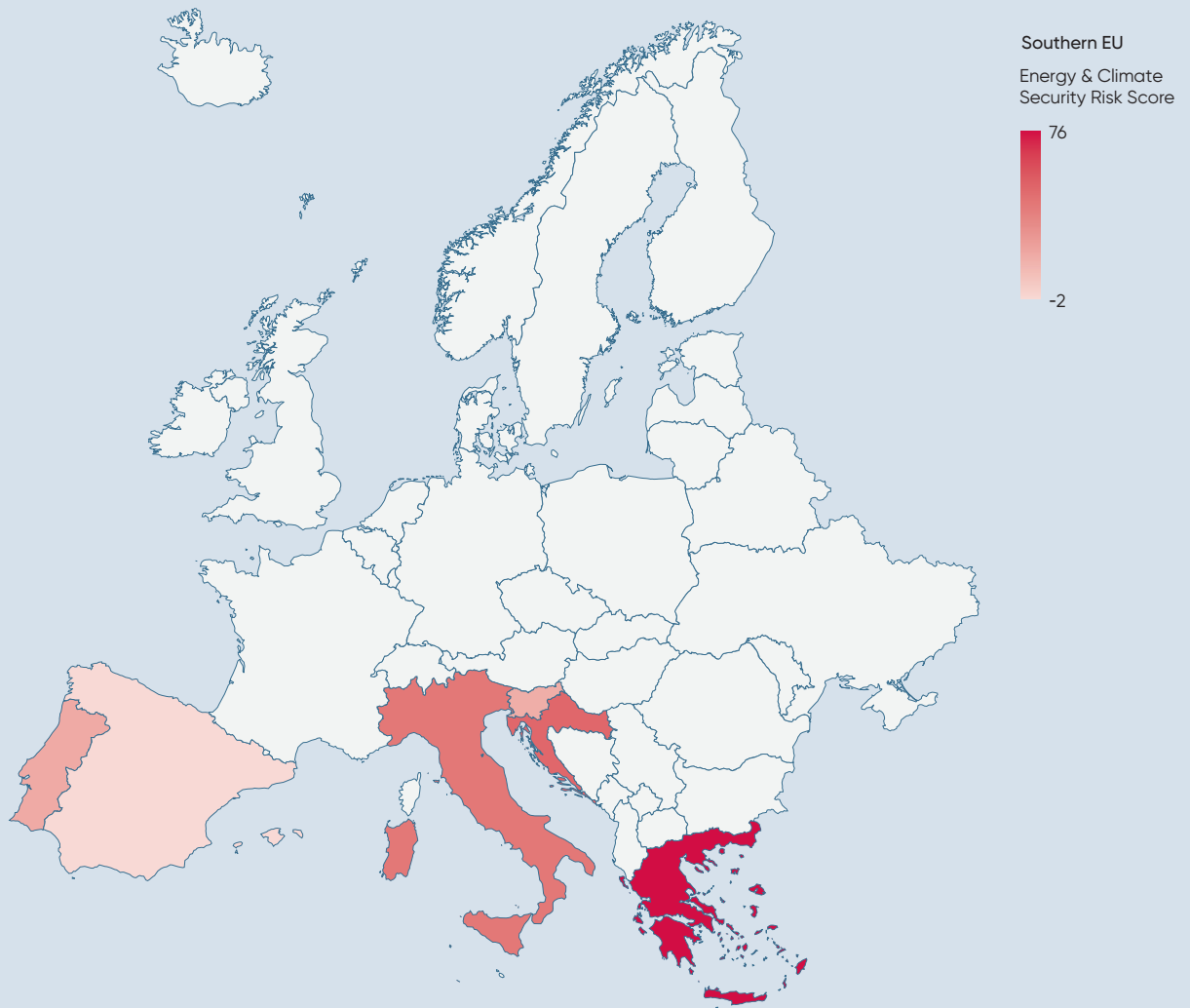
⁸¹ Patrahau, I., and van Geuns, L., “The Dutch tank storage sector: Navigating uncertainty in the energy transition”, *Energy storage in transition series*, The Hague Centre for Strategic Studies (HCSS), October 2024.

Another underlying challenge lies in balancing its dual identity: as a high-income, industrialized economy and as a logistical center for fossil fuel trade in Europe (including of Russian oil and gas). The Netherlands continues to house major oil refining, shipping, and fossil fuel trading operations, which makes full decarbonization more difficult. At the same time, the country's extensive storage, grid and cross-border interconnection

capacity have made it an anchor of European energy reliability, especially in periods of regional shortfalls.

The next phase of its transition will require scaling clean energy deployment, accelerating emissions reductions in hard-to-abate sectors, and mitigating social impacts of rising costs, while maintaining its crucial role in regional energy flows.

SOUTHERN EUROPE



Countries Included:

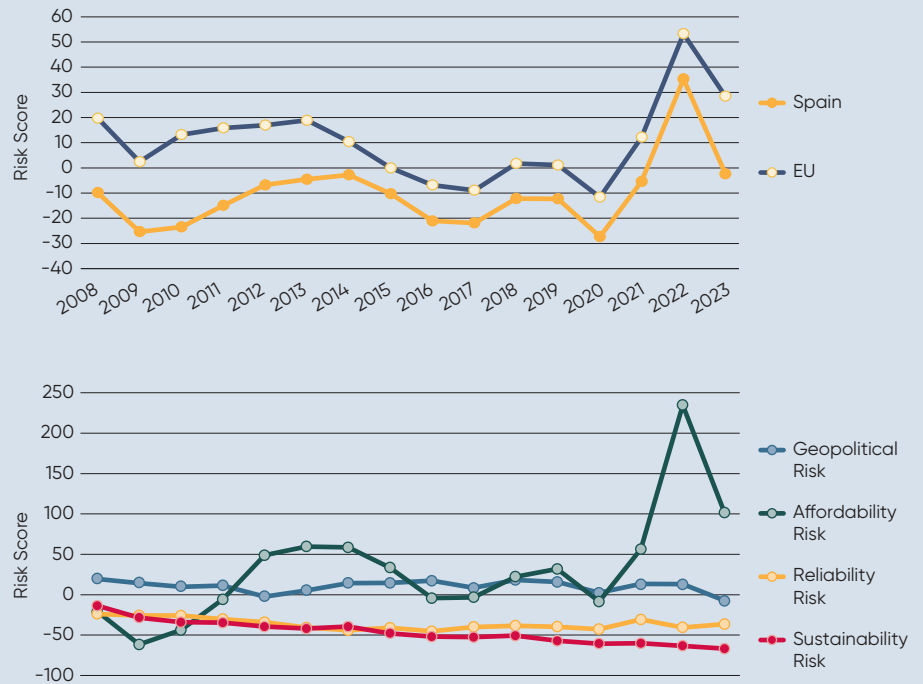
- Spain
- Croatia
- Greece
- Italy
- Portugal
- Slovenia

Southern EU countries have made notable strides in expanding renewable energy, leveraging solar, wind, and hydro resources to reduce sustainability risks. Spain and Portugal, in particular, benefit from diversified energy systems and robust LNG infrastructure, contributing to low geopolitical risks. However, security of supply vulnerabilities remain high in countries like Italy and Greece due to the still heavy reliance on fossil fuel imports, including Russian gas. The region has also faced an acute energy affordability crisis after 2021, most pronounced in Italy and Greece, whose power systems have been dominated by much more expensive gas.



SPAIN

Energy Security Risk Score Summary	
2023 Energy Security Risk Score	-2
Geopolitical Risk	-7
Affordability Risk	102
Reliability Risk	-36
Sustainability Risk	-67
ECSRI Score in 2015	-10
Overall Rank	6



Spain has emerged as one of Europe’s most resilient energy consumers, steadily reducing its exposure to geopolitical risks and fossil fuel dependence through consistent investments in renewables and strategic diversification of supply. However, as the country’s transition accelerates, the country is also facing growing reliability risks that could complicate future progress without strengthening the power grid and the massive uptake of energy storage solutions.

Unlike many of its European peers, Spain has had only a limited dependence on Russian gas, relying instead on a broad portfolio of LNG imports from countries like the U.S., Nigeria, and Algeria. In fact, Spain has become a key enabler of the gradual Russian gas phaseout in much of Europe as the country has a robust network of six LNG regasification plants, strategically located to ensure secure and diversified natural gas supply with a total capacity of almost 69 bcm/yr, amounting to 25% of the EU’s total gas imports in 2024. The expansion of the country’s LNG infrastructure and interconnection with France has not only reinforced Spain’s own supply security but also enabled it to serve as a buffer and backstop for other EU member states during crisis periods.

Despite this key role for Europe’s diversification, Spain has also increased the imports of Russian LNG since the invasion, and Russian LNG exports to the country make up around a quarter of its total purchases⁸². Although some of these volumes are linked to long-term LNG supply contracts with the second largest Russian gas company, Novatek, much of the volumes are actually not destined for the Spanish market but are reexported to the rest of Europe revealing the broader persistence of Russian gas dependence in the EU.

Spain’s growing renewable energy base has also contributed to lowering the country’s overall geopolitical risk. Over the past decade, the country has seen an enormous jump in its installed wind and solar capacity, with renewables now accounting for more than half of the annual electricity generation. This has not only helped decouple Spain’s energy system from imported fossil fuels but also supported the full phaseout of coal. Spain heavily emphasizes the “just transition” policy to ensure communities are not negatively impacted by decarbonization, leading to strong public backing of renewables.⁸³

⁸² Reuters, “Russian LNG accounts for a quarter of Spanish gas imports in March”, 10 April 2024.

⁸³ Lázaro Touza, L. et al., *From phasing-out to phasing-in: Lessons from Spain’s just transition governance framework*, Elcano Royal Institute, 2025.

However, while Spain has succeeded in enhancing energy security and sustainability, affordability has become an increasingly complex challenge. Energy prices for households and industry surged following the 2021 energy crisis and the subsequent rise in global gas prices, affecting the costs of gas-fired power balancing in the country. Between 2021 and 2024, the 20% increase in the share of renewables has led to a 7.5% decrease in electricity prices from 2023 and 2024, showing the increasing benefit of renewable expansion.⁸⁴ Government interventions, such as temporary price caps and tax reductions, have been necessary to stabilize the situation, but affordability concerns persist, especially for lower-income households.

On the reliability front, Spain has faced one of its biggest tests so far during the 28 April, 2025 Iberian Peninsula power blackout. The country's position at the southwestern edge of Europe has historically limited its cross-border electricity exchanges, which exacerbated the severity of the crisis when the grid lost inertia after the failure of several solar PV generators and balancing units did not respond adequately. Spain has benefited from strong hydropower and gas storage capabilities, which have helped maintain system resilience during times of peak demand but as the renewables share

consistently go above 60-70% of the total power production, the strain on the grid to maintain stability has been increasing. The government will have to ramp up the strategic placement of battery storage facilities across the country, as well as boost the interconnection capacity to France to find ways to evacuate the surplus green electricity.

Sustainability has been the brightest spot in Spain's energy profile. Over the past 15 years, emissions intensity and fossil fuel reliance have declined steadily, driven by an ambitious national strategy for clean energy deployment and decarbonization. Apart from the wind and solar investments, Spain is also using regional industrial clusters such as the Basque "super cluster" and Andalusian Green Hydrogen Valley to scale up clean energy solutions also in the industrial sectors. These clusters enable systemic solutions across the entire value chains (e.g., hydrogen, CCS, storage), which will continue to decarbonize Spain's economy.⁸⁵

Spain's experience shows that early diversification and renewables leadership can deliver strong returns in energy security but sustaining public and political support will require ensuring that the benefits of transition are equitably shared.

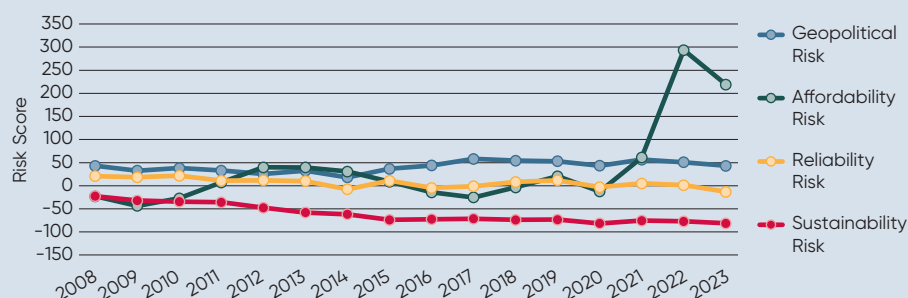
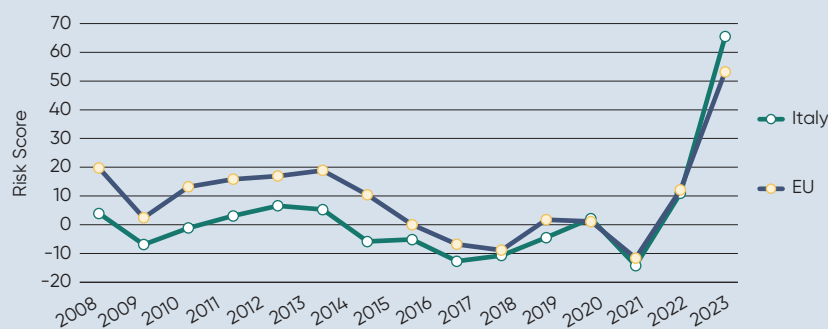
⁸⁴ Cubero, J. et al., *Spain: Reaping the benefits of renewable energy in the Spanish economy*, BBVA Research, 2025.

⁸⁵ Vila, C., and Mettler, A., "Spain is leveraging industrial clusters to lead Europe's energy transition", *World Economic Forum*, 16 January 2025.



ITALY

Energy Security Risk Score Summary	
2023 Energy Security Risk Score	41
Geopolitical Risk	42
Affordability Risk	218
Reliability Risk	-14
Sustainability Risk	-28
ECSRI Score in 2015	-5
Overall Rank	18



Italy’s energy and climate security profile is shaped by the country’s high dependence on natural gas and modest progress on decarbonization. While it is among the top performers in sustainability due to its high circularity and recycling rates, Italy remains one of the EU countries with the highest geopolitical energy risks. The dependence on natural gas for electricity generation and household heating makes it particularly vulnerable to external supply shocks.⁸⁶ In recent years, gas has accounted for between 35% and 40% of Italy’s total energy consumption, one of the highest shares in the EU and significantly higher than in Germany or Austria, which have typically suffered most from their gas dependence on Russia.

While Italy has increased the diversity of its natural gas imports, most supplies still originate from undemocratic or unstable regimes, including Russia, Libya, Azerbaijan, and Qatar. In 2022, Italy sourced 40% of its gas from Russia.⁸⁷ Even though the country has taken steps to secure alternative suppliers and improve its resilience, until the end of the Russian gas transit agreement with Ukraine on 1 January, 2025 Italy actually increased Russian pipeline gas imports via Austria. Now only around 5% of the gas imports of the country come from

Russia, mostly via LNG purchases. Italy has replaced most of the Russian gas imports with increased supply from Africa and from the global LNG market.

The high share of gas in the energy mix (51% of electricity generation and 38% of the total energy supply), has led to a surge in affordability risks in 2022 and 2023. Despite short-term measures to cushion consumers, including price caps and subsidies, Italian households are facing some of the highest electricity prices in Europe.⁸⁸ The share of energy poor consumers in 2023 reached around 10%, which has translated in a significant number of families unable to heat or cool their homes adequately, impacting their health and overall well-being. The problem is not uniform, with Southern Italy experiencing higher rates compared to the North due to regional economic disparities and infrastructure differences.

Italy’s reliability risks have been historically low. The overreliance of the country’s grid on natural gas power plants and the extensive interconnections with liquid markets in Switzerland, Austria and Greece, has alleviated the strain on the grid even during peak demand period.

⁸⁶ Raimondi, P. P., *Italy’s energy-intensive industries amid competitiveness and decarbonisation*, Istituto Affari Internazionali (IAI), 2025.

⁸⁷ Vasilj, L., “Energy security: A new argument for rapid decarbonisation in Italy”, *ECCO Climate*, 23 September 2022.

⁸⁸ ECCO Climate, “Phasing out gas dependency through energy savings and renewables”, 3 March 2022.

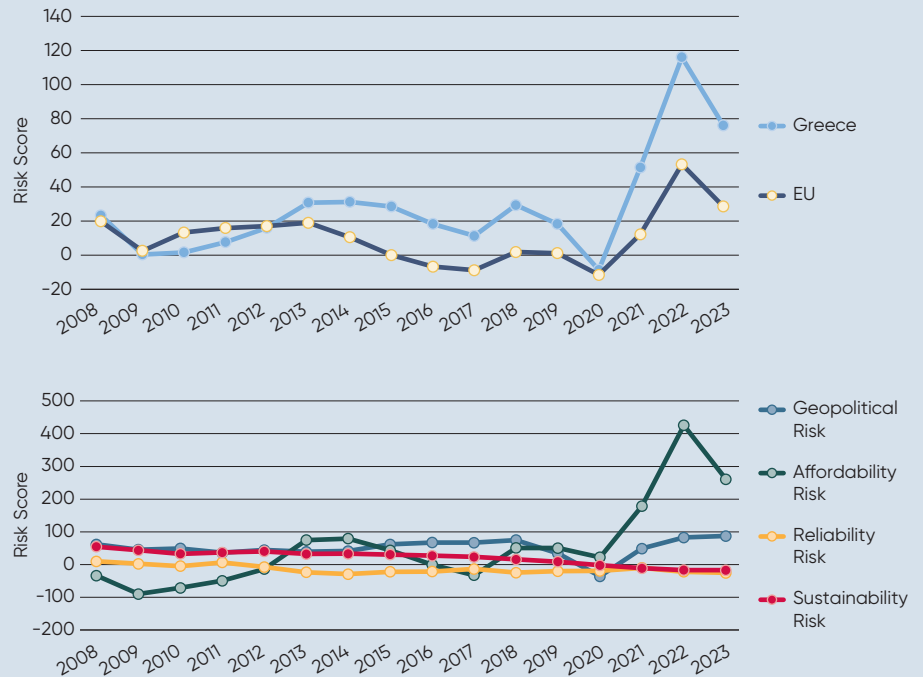
Where Italy has lagged behind the most in improving its energy and climate security position is its failure to accelerate the energy transition. While Italy has made progress in renewable energy, particularly solar power, it still lags behind in achieving its overall targets and is struggling with issues like grid modernization, permitting delays, and political uncertainty. Even so, the share of renewables have crept up since 2021, reaching 41% of the total power demand in 2024 thanks to the expansion of solar PV investments and more robust hydro power output.

Despite these challenges, Italy excels in circular economy and material efficiency indicators. It ranks among the EU's top performers in the Circular Material Use Rate, thanks in part to its long-standing recycling traditions and waste-reduction policies. Italy's leadership in resource efficiency provides a strong foundation for building a more sustainable economy.



GREECE

Energy Security Risk Score Summary	
2023 Energy Security Risk Score	76
Geopolitical Risk	87
Affordability Risk	261
Reliability Risk	-25
Sustainability Risk	-17
ECSRI Score in 2015	28
Overall Rank	23



Greece continues to face persistent challenges in achieving a balanced energy system, struggling across all three pillars of the energy trilemma, making the country one of the worst performers in the ECSRI for 2023 (ranked 23). Its high dependence on imported fossil fuels, particularly oil and natural gas, places it among the EU countries with the highest geopolitical and reliability risks. In 2023, Greece had the highest petroleum import security risk and the sixth-highest natural gas import security risk, underlining its limited diversification and high vulnerability to external supply shocks. While Europe continued to reduce its reliance on fossil fuels in electricity generation since 2022, Greece went in the opposite direction by increasing its use of gas-fired power by 37%, the third highest share in the EU. This shift has had major consequences for Greece’s electricity prices and climate commitments.⁸⁹ While Greece initially succeeded in reducing the share of Russian natural gas imports from over 40% in 2021 to 17.5% in 2022, Russian gas rebounded to around 55% in 2024 on the back of record-high supply via the TurkStream gas pipeline – the largest Russian gas export route in Europe.

Greek shippers have also been among the most important enablers of the continued Russian oil exports

moving around 20% of the overall volumes.⁹⁰ Greek coasts were also major hotspots for Russian ship-to-ship transfers until April 2024, when stringent measures were introduced to limit such practices.

Greece faces high sustainability risks due to its failure to implement EU climate policies. Greece is also among the top eight most emissions- and energy-intensive countries in the EU, and one of the five countries with the highest CO₂ costs per GDP. These risks have intensified with the rising cost of EU carbon allowances. Greece’s reliance on hard-to-decarbonize industries and coal-fired generation has made it particularly vulnerable to the evolving structure of the EU ETS.

Although Greece has made policy efforts to accelerate its clean energy transition—such as passing a special Off-shore Wind Law in 2023, only 21% of its overall energy mix came from renewables in 2022. This falls well short of EU targets and leaves Greece still heavily reliant on fossil fuels. In its efforts to phase out lignite, Greece has turned to natural gas as a bridge fuel, which successfully reduced its carbon intensity but increased its exposure to global gas market volatility. During the 2021 energy crisis, this strategy backfired as gas prices surged, triggering a significant rise in affordability risks. The last three

⁸⁹ Mantzaris, N., “Gas in electricity production: Greece diverging from Europe”, *The Green Tank*, 5 August 2024.

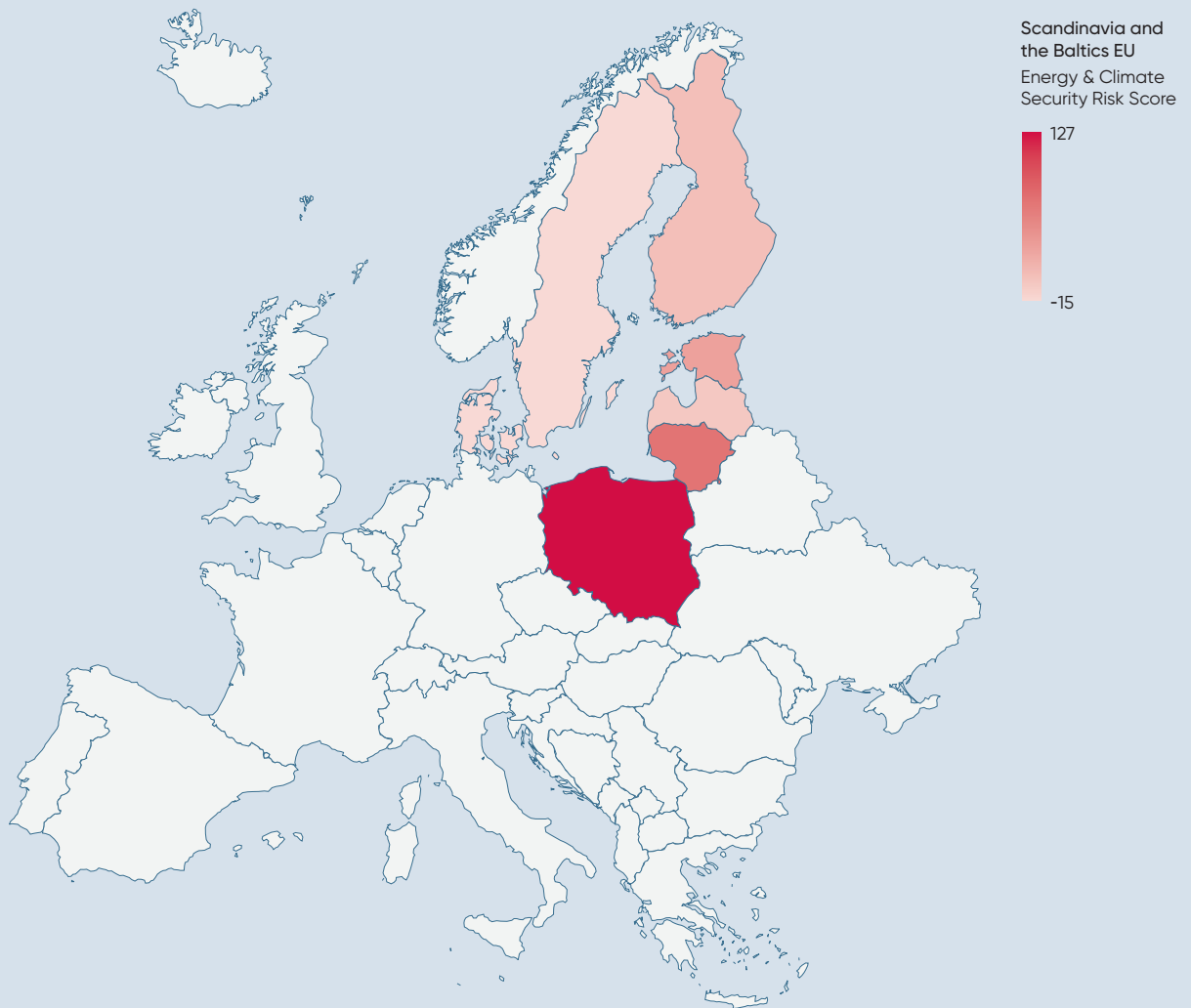
⁹⁰ Saul, J., and Maltezos, R., “Greek fleet to keep shipping approved Russian oil despite new EU sanctions, sources say”, *Reuters*, 18 July 2025.

years have seen a significant reverse of this strategy as Greek companies have invested billions in solar and wind. Renewables increased to 55% of the total power generation in 2024 up from just 29% in 2021.

While the high level of ambition of the Greek government's energy strategic documents including its National Energy and Climate Plan represents a big step in the right direction, the country will face a highly complex task in transforming its energy system into one that is resilient, equitable, and environmentally

sustainable. The country aims to achieve climate neutrality by 2050 and has set ambitious targets, including a 58% reduction in net GHG emissions below 1990 levels by 2030 on the back of a complete lignite phaseout by 2028 and an 80% share of renewables in the power mix. To achieve this, the government has also committed billions of national and EU funding to battery storage and regional power interconnections, the full electrification of heating and the industrial sector, and the rollout of hydrogen hubs based on research and innovation support in transition regions.

SCANDINAVIA AND THE BALTICS



Countries Included:

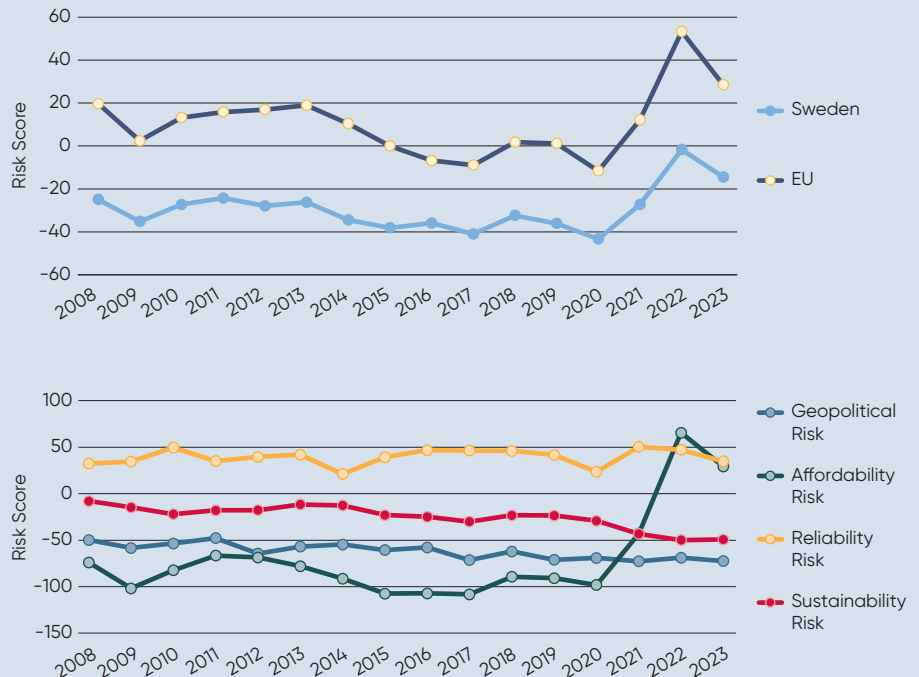
- Denmark
- Finland
- Sweden
- Estonia
- Latvia
- Lithuania
- Poland

Scandinavian and Baltic countries have a relatively low geopolitical risk profile due to their successful energy diversification strategies, access to seaborne imports, and proximity to reliable power and gas suppliers such as Norway. Denmark and Sweden are renewable energy leaders, with Denmark exporting wind energy technology all across the world and Sweden contributing heavily to the EU's raw material supply through its iron ore and metal mining sectors. Meanwhile, the Baltic states face greater affordability and reliability risks due to their open, smaller markets and limited infrastructure, making them more vulnerable to global energy price volatility and supply disruptions. Despite these challenges, the region's investment in renewables and domestic resource extraction contributes to moderate overall energy and climate security scores.



SWEDEN

Energy Security Risk Score Summary	
2023 Energy Security Risk Score	-15
Geopolitical Risk	-72
Affordability Risk	29
Reliability Risk	35
Sustainability Risk	-49
ECSRI Score in 2015	-38
Overall Rank	4



Sweden has long ranked among Europe’s top performers in energy security, benefiting from a uniquely balanced and diversified energy system. Its strong foundation in domestically sourced biomass, hydro and nuclear power has allowed the country to maintain low geopolitical exposure and low reliability risk, while supporting ambitious sustainability goals. However, recent global energy market disruptions have tested the country’s resilience to affordability pressures.

A central pillar of Sweden’s energy strategy has been its ability to minimize its dependence on imported fossil fuels. Hydropower and nuclear have formed the backbone of the electricity mix for decades, buttressed in recent years by growing investments in on and offshore wind power. In addition, hydropower alone supplies 25% of Sweden’s annual electricity consumption.⁹¹ This diversified and low-carbon mix has insulated Sweden from the geopolitical turbulence affecting countries more reliant on natural gas or coal imports. As a result, Sweden has consistently maintained one of the lowest risks to supply disruptions and price volatility tied.

Reliability is another hallmark of Sweden’s energy system. Decades of investment in grid infrastructure, domestic production capacity, and regional interconnections have created a robust and flexible network. This has enabled Sweden not only to meet its own demand with high levels of consistency, but also to export electricity to neighboring countries including Finland, Denmark, and Germany, contributing to the broader European grid stability. As Sweden’s electricity demand is expected to triple by 2050, driven by the electrification of industry and transport, Sweden has continued to reform its market structure to incentivize the huge private investments necessary for this transition.⁹²

Sweden also leads on the sustainability front. The country has aggressively pursued decarbonization, driving down emissions. Policies supporting the electrification of transport, energy efficiency in buildings, and clean industrial innovation have all contributed to steady environmental gains over the past 15 years. Sweden’s commitment to net-zero by 2045 places it among the most ambitious in the world, and the country is well on track to meet its interim targets.

⁹¹ Xylia, M., Bin Ashraf, F., and Barquet, K., *Hydropower development in the energy transition: Perspectives from northern Sweden*, SEI Policy Brief No. 2023-048, Stockholm Environment Institute, 2023.

⁹² Energiforsk, *Contracts for Difference (CfD) in the Swedish Electricity Market*, Energiforsk Report 2024:991.

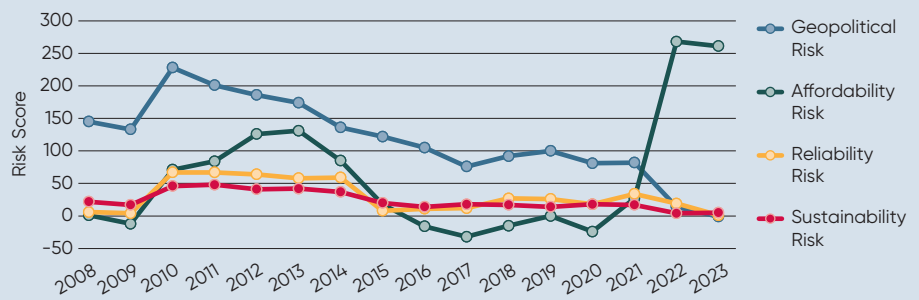
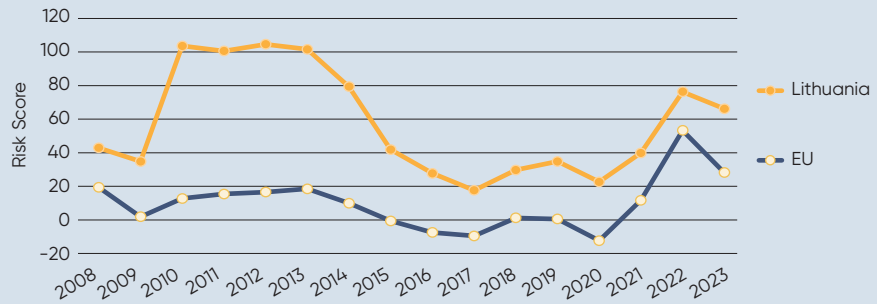
In addition to its strengths in the energy domain, Sweden is also a key player in the EU's raw materials landscape. It is the EU's largest producer of iron ore, accounting for approximately 80–90% of the bloc's total output. Sweden also holds significant deposits of copper, zinc, and lead—critical resources for the green and digital transitions. While Sweden lacks extensive refining capacity and exports large volumes of unprocessed ores, this trade dynamic reduces its risk exposure in terms of raw material security.

Sweden's experience underscores the importance of long-term structural resilience in energy systems—but also reveals that even high-performing countries can face affordability shocks in times of market turmoil. As Sweden continues to play a leadership role in the EU's clean energy transition, its challenge will be to ensure that energy and critical raw materials remain not only secure and sustainable, but also accessible and affordable for all citizens in an increasingly complex and interconnected global landscape.



LITHUANIA

Energy Security Risk Score Summary	
2023 Energy Security Risk Score	66
Geopolitical Risk	-1
Affordability Risk	261
Reliability Risk	1
Sustainability Risk	5
ECSRI Score in 2015	42
Overall Rank	21



Lithuania has significantly strengthened its geopolitical position over the past decade. Once one of the most energy insecure countries in the EU, with extremely high risk scores for gas and power security of supplies between 2008 and 2014, Lithuania has steadily reduced its dependence on Russian energy. By 2023, its geopolitical risk had dropped to nearly zero from a high of 228 in 2010. This trend reflects years of investment in energy diversification, regional grid interconnection through the Baltic Energy Market Interconnection Plan (BEMIP), and the strategic use of its Klaipėda LNG terminal, which allowed Lithuania to eliminate Russian gas imports by 2022.

Despite the progress on diversification, Lithuania continues to face serious affordability challenges. In both 2022 and 2023, it recorded some of the highest affordability risk scores in the EU, driven largely by its exposure to volatile LNG and oil markets. The country’s small energy market and limited bargaining power have left it vulnerable to global price swings. In addition, Lithuania’s high energy and emissions intensity—among the top three in the EU—further exacerbates this challenge, as its economy remains heavily reliant on carbon-intensive fuels for both power generation and for its heavy industry.

Reliability risks have fallen over the last decade but remain a concern due to Lithuania’s heavy reliance on energy imports and infrastructure constraints. Although the country has improved its energy system through regional cooperation, grid modernization, and the boosting of its LNG storage capacity, Lithuania remains exposed to disruptions.

Continued investment in interconnectors with Poland and Sweden, alongside the completion of the Baltic synchronization process in 2025, will be key to strengthening resilience. Additionally, in 2023, Lithuania’s electricity imports fell by 9.6%, yet imports still accounted for 77.9% of total consumption. Domestic electricity generation rose to 5.66 TWh, while consumption slightly declined to 11.83 TWh.⁹³

On sustainability, while not among the worst performers, Lithuania has struggled to shift away from fossil fuels or scale up renewable energy deployment in a way that matches EU climate ambitions. Between 2008 and 2023, there was only a modest reduction in sustainability risks. The country’s emissions intensity remains high, reflecting a power and industrial sector still heavily reliant on gas and oil products. Under current policies, achieving the EU’s target of a 55% net reduction in

⁹³ National Energy Regulatory Council (NERC), *Annual Report on Electricity and Natural Gas Markets submitted to the European Commission – 2023*, July 2024.

GHG emissions by 2030 compared to 1990 levels will be challenging, especially in non-ETS sectors.⁹⁴ More targeted investment in wind, solar, and building energy efficiency will be necessary to bring Lithuania's energy system in line with EU decarbonization pathways.

Lithuania's energy profile is one of contrasts—marked progress on reducing geopolitical vulnerability, but persistent weaknesses in affordability, emissions,

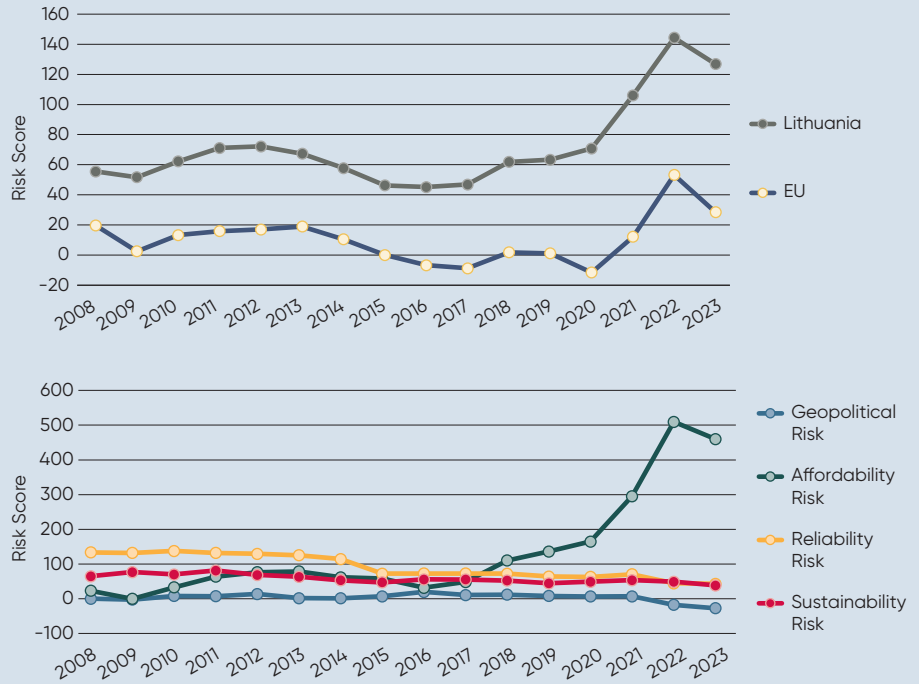
and system flexibility. Its experience underscores the particular challenges faced by smaller energy markets, which may be quick to decouple from politically risky suppliers but still remain deeply vulnerable to price shocks and import dependencies. To build a secure and sustainable future, Lithuania will need to pair its diversification success with stronger action on decarbonization, energy efficiency, and long-term price stability.

⁹⁴ Atkočiūnas, V. et al., *Lithuania's First Biennial Transparency Report under the Paris Agreement*, Ministry of Environment of the Republic of Lithuania, 2024.



POLAND

Energy Security Risk Score Summary	
2023 Energy Security Risk Score	127
Geopolitical Risk	-27
Affordability Risk	460
Reliability Risk	43
Sustainability Risk	39
ECSRI Score in 2015	46
Overall Rank	25



Poland ranks as the worst energy and climate security performer in the EU according to the ECSRI. However, the results bely a stark contrast. Its geopolitical risks are low as the country relies largely on domestic energy resource but households and businesses face very high affordability and sustainability risks. Thanks to abundant domestic coal reserves and a strategic reduction in Russian energy imports, Poland has significantly reduced its exposure to foreign supply disruptions. Between 2014 and 2021, Poland cut Russian gas imports by 14% – despite increasing its overall gas consumption by 35% – and completely ended Russian gas imports by Q1 2023.⁹⁵ However, the coal-heavy power mix, which accounted for 50% of installed capacity in 2023, comes at a rising environmental and economic cost.

Although its reliance on domestic lignite insulates it from some geopolitical shocks, the country’s heavy emissions profile makes it particularly vulnerable under the EU ETS. Affordability risks, already high, worsened during the 2021 energy crisis, with non-household consumers now paying among the highest electricity prices in the EU, even as regulated prices shield most households.

Poland is in the midst of a complex transition. While onshore wind and solar have expanded and plans for 11 GW of offshore wind and new nuclear capacity are underway, the country is also investing heavily in natural gas infrastructure and must drastically increase renewable energy deployment to reach its climate goals.⁹⁶ New LNG terminals and gas-fired power plants, including PGE’s Dolna Odra expansion, risk creating a technological lock-in to fossil fuels, especially given their long payback periods and incompatibility with net-zero timelines.

Poland’s low-capacity diversity further amplifies reliability concerns. Only Germany has more installed coal capacity, but in Germany it represents just 16% of the generation mix, compared to 50% in Poland. Much of Poland’s coal infrastructure is aging and inefficient, raising the risk of unplanned outages. In addition, climate-related disruptions, such as droughts and heatwaves, threaten coal plant cooling operations, putting further pressure on the system during peak demand periods.

Gas storage also emerged as a key vulnerability in 2023. Despite new EU storage regulations, Poland’s gas

⁹⁵ Polish Economic Institute, “Poland leads the way in Europe by reducing its dependence on Russian gas”, 20 June 2023.

⁹⁶ Forum Energii, “Polskie Sieci 2040: Gotowe na 90 GW OZE” [Polish Electricity Networks 2040: Ready for 90 GW of Renewables], 22 January 2025.

stocks risk increased – the only country in the EU to see such a trend that year. Average storage levels dropped from 87% in 2022 to 80% in 2023. Poland’s gas storage capacity remains limited relative to growing demand, particularly concerning, if gas is expected to play a larger role in power generation.

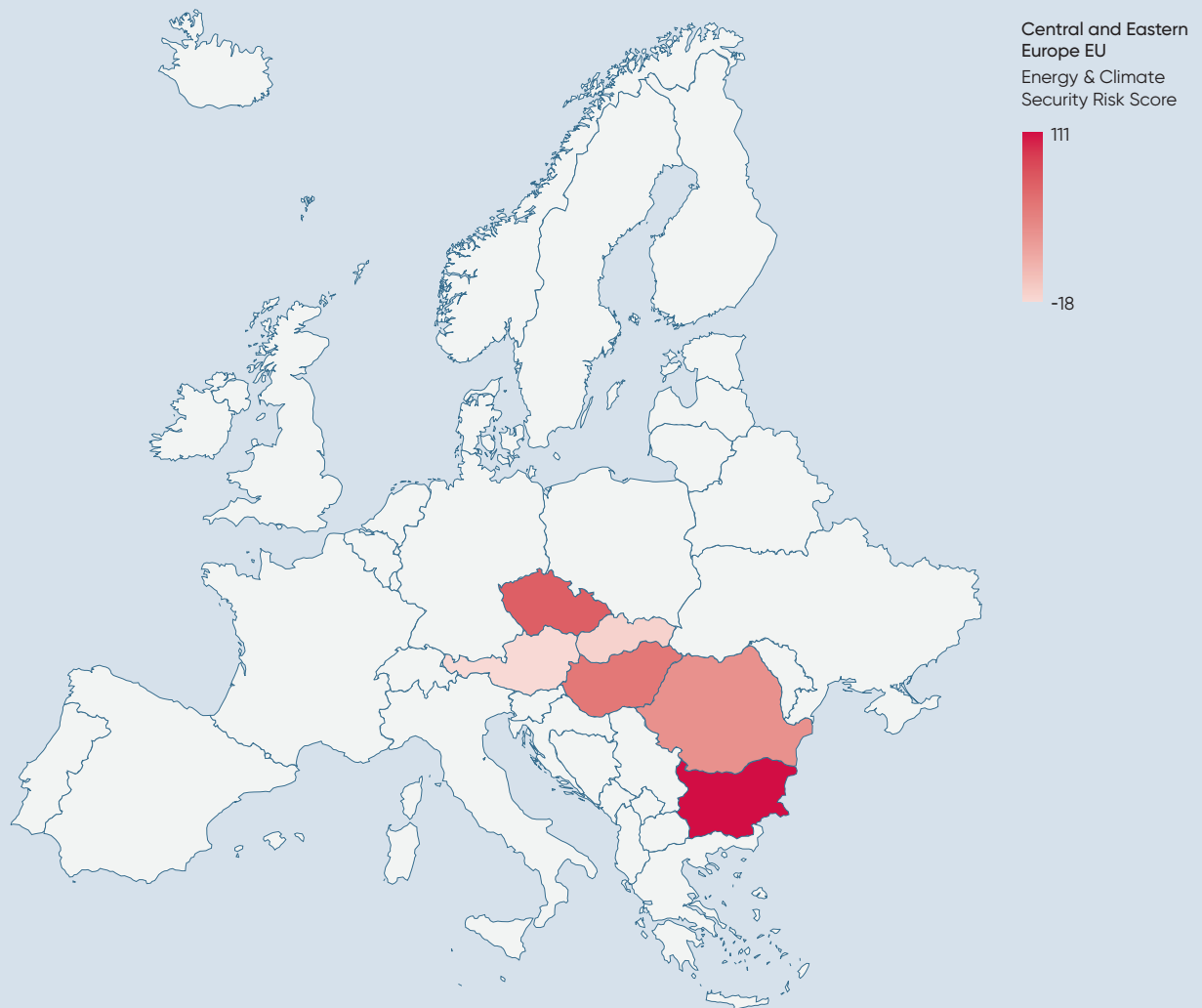
At the same time, Poland is emerging as a major clean tech exporter, particularly of batteries. Lithium-ion battery exports reached €8.24 billion in 2022, a 38-fold increase since 2017. Poland has also managed to decouple economic growth from material consumption, with below-EU-average scores for waste per capita and material footprint. This progress reflects a broader economic shift

toward services, IT, and advanced manufacturing, distinguishing Poland from other energy-intensive economies in the region.

Social and political factors continue to shape the pace of transition. Coal mining employs around 75,000 people, making the phaseout politically sensitive. However, €3.5 billion from the EU Social Climate Fund has been allocated to support retraining, green job creation, and infrastructure modernization in coal regions, making Poland the largest beneficiary.⁹⁷ Poland’s challenge will be managing this transition while avoiding new dependencies and ensuring that its energy system becomes not just secure, but also affordable and sustainable in the long run.

⁹⁷ Reform Institute, “A secure and competitive Europe or a green Europe – why not both? Summary of the Think2030 Dialogue Poland”, *Press release*, 1 April 2025.

CENTRAL AND EASTERN EUROPE



Countries Included:

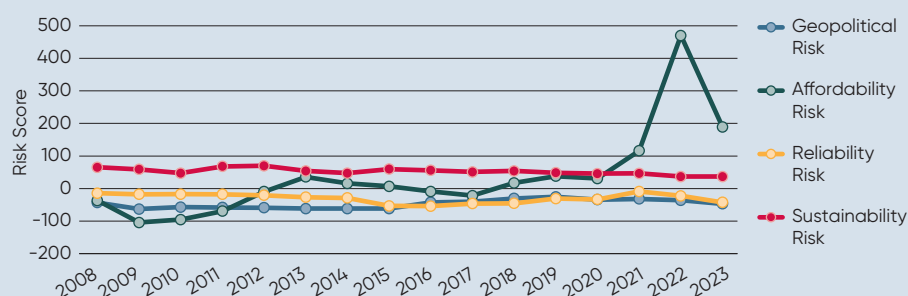
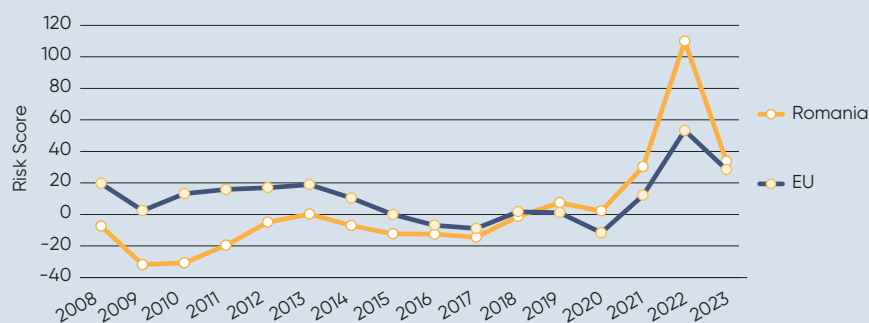
- Bulgaria
- Hungary
- Czechia
- Slovakia
- Romania
- Austria

Central and Eastern European countries continue to face high geopolitical and sustainability risks, driven by the region's historic dependence on fossil fuel imports, particularly from Russia, and a relatively slower green transition. Coal remains a dominant source of electricity in Poland, Bulgaria and Czechia, which, because of rising carbon prices, has translated in high affordability risks. Nonetheless, the region benefits from low reliability risk scores, supported by robust gas infrastructure, regional interconnections, and large storage capacity in Slovakia, Hungary, and Austria. While efforts to diversify supply and strengthen regional cooperation have helped reduce exposure to Russian energy, on the sustainability front, the energy transition process has lagged behind with the exception of Austria and Romania. Most of the private investment has gone into solar PV plants, while wind energy projects have been stalled by slow permitting processes and social opposition.



ROMANIA

Energy Security Risk Score Summary	
2023 Energy Security Risk Score	34
Geopolitical Risk	-47
Affordability Risk	189
Reliability Risk	-42
Sustainability Risk	37
ECSRI Score in 2015	-12
Overall Rank	16



Romania stands out as a positive outlier in Southeast Europe, offering a rare example of energy system resilience grounded in strong domestic production and low exposure to geopolitical risks. Its reliance on domestic natural gas extraction (covering between 80 and 90% of domestic consumption) has positioned it as one of the most energy secure EU members. The development of the country's offshore gas resources in the Black Sea will transform the country in the largest European gas producer by 2030. In a region where many countries remain heavily dependent on Russian imports, Romania has built a more self-sufficient energy model that provides stability in uncertain geopolitical conditions.⁹⁸ As a result, the country had the seventh-lowest geopolitical risk in the EU in 2023. Romania now ranks third in the EU for lowest natural gas import risk, behind only Denmark and Sweden.

Romania's reliability of supply also remains robust, supported by a balanced mix of hydro, nuclear, coal, and gas in the power mix. Recent infrastructure investments and regional interconnections have helped maintain system stability even during moments of broader market stress.

However, the diversity of the power system is somewhat offset by the country's lagging transition performance. The country remains somewhat reliant on coal, which is yet to be phased out from the power and industrial sectors (steel production). While some progress has been made on emissions, renewable investment has been relatively slow.⁹⁹ Even so, the country has set out a target to reduce GHG emissions by 78% until 2030. The country's Parliament also passed a dedicated offshore wind energy law, which aims to open tenders for the addition of 3 GW of offshore wind energy plants by 2035.

In addition, the planned nuclear expansion at the Cernavodă power plant could provide a lower-carbon backbone in the future, though questions remain over timelines and financing, as the project has suffered from decade-long delays due to political indecision and poor investment strategies.¹⁰⁰

Affordability presents another growing challenge. Despite its strong domestic energy base, Romania has not been immune to the cost pressures of the wider European energy crisis. Energy poverty remains widespread, particularly in rural areas and among

⁹⁸ Miu, L. et al., *Building Momentum for the Long-Term CCS Deployment in the CEE Region: CCS National Roadmap Romania*, Energy Policy Group, 2024.

⁹⁹ Energy Policy Group, *The role of hydrogen in Romania's low-carbon economy: Results from the Annual Decarbonisation Perspective Model for Romania*, EPG Policy Papers, October 2024.

¹⁰⁰ Gusilov, E., *Romania's approach to energy transition: Too little, too slow*, Policy Paper, Romania Energy Center (ROEC), April 2023.

low-income households. While the government has introduced price caps and compensation schemes to protect consumers, these are short-term fixes. Balancing social equity with long-term investment in clean and modern infrastructure will be critical to ensuring an inclusive and sustainable energy transition.

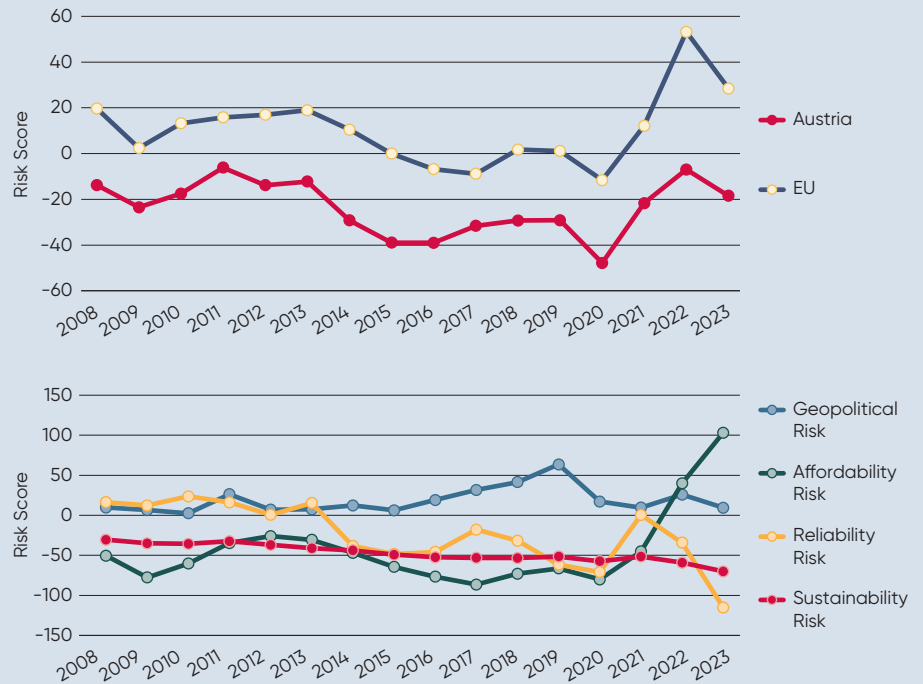
Finally, Romania holds underutilized potential in Europe's evolving critical raw materials strategy. With known reserves of copper and rare earths, the country

could become an important contributor to the EU supply chain resilience for green technologies. Tapping into this potential would not only support Romania's economic competitiveness but also enhance Europe's strategic autonomy in the clean energy transition. Overall, Romania has leveraged its domestic production base to strengthen energy security, but the next stage will require accelerated decarbonization and deeper affordability reforms to ensure the system remains secure, inclusive, and sustainable.



AUSTRIA

Energy Security Risk Score Summary	
2023 Energy Security Risk Score	-18
Geopolitical Risk	9
Affordability Risk	103
Reliability Risk	-115
Sustainability Risk	-70
ECSRI Score in 2015	-39
Overall Rank	2



Austria is ranked as the second most energy secure country in the EU according to the ECSRI. The country has long benefited from a clean and efficient electricity system, anchored in hydropower and a high share of renewables. With approximately 80% of its electricity coming from renewable sources – more than half of that from hydro – Austria ranks among the EU’s best performers on sustainability.¹⁰¹ Its energy intensity and carbon emissions per kWh are low, and its building and transport systems are among the most energy efficient. However, this renewable-heavy mix has introduced new vulnerabilities: Austria is increasingly exposed to climate-driven risks such as droughts and heatwaves, which threaten hydropower reliability and underscore the need for backup flexibility.

In contrast to its sustainability strength, Austria’s geopolitical risk has worsened in recent years due to its persistent dependence on Russian natural gas. Although it briefly reduced Russian gas imports after the start of the Ukraine war, by 2024, around 80% of its gas once again came from Russia—one of the highest shares in the EU. A legal dispute between Gazprom and Austrian energy company OMV triggered an announced supply

halt in late 2024, but in practice, Russian gas continued to reach Austria via spot market trading.¹⁰² Austria has taken steps to diversify—importing LNG via Germany and Italy and tapping into Norwegian pipeline gas—but as of 2023, it remained one of the most exposed countries in Europe to Russian gas supply risk.

Reliability has also emerged as a growing area of concern. After several years of improvement, Austria’s reliability risk worsened significantly by 2023, driven by growing challenges in electricity capacity diversity. The country’s overreliance on hydropower means its grid flexibility is increasingly tested during extreme weather events. While strong regional interconnections and ample gas storage—almost full at the end of 2024 due to EU preparedness regulations—provide some buffer, Austria’s capacity to maintain stable electricity supply under stress is being stretched. As decarbonization accelerates, greater investment in grid modernization, battery storage, and backup generation will be needed to stabilize reliability.

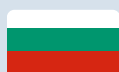
Affordability also deteriorated sharply in 2023, making Austria one of only a few countries in the EU where

¹⁰¹ Oesterreichs Energie, “The power of renewables: How our electricity system works” (n.d.).

¹⁰² Zhdannikov, D., and Schwarz-Goerlich, A., *Austria’s half-century bond with Gazprom ended by gas seizure, sources say*, *Reuters*, 25 November 2024.

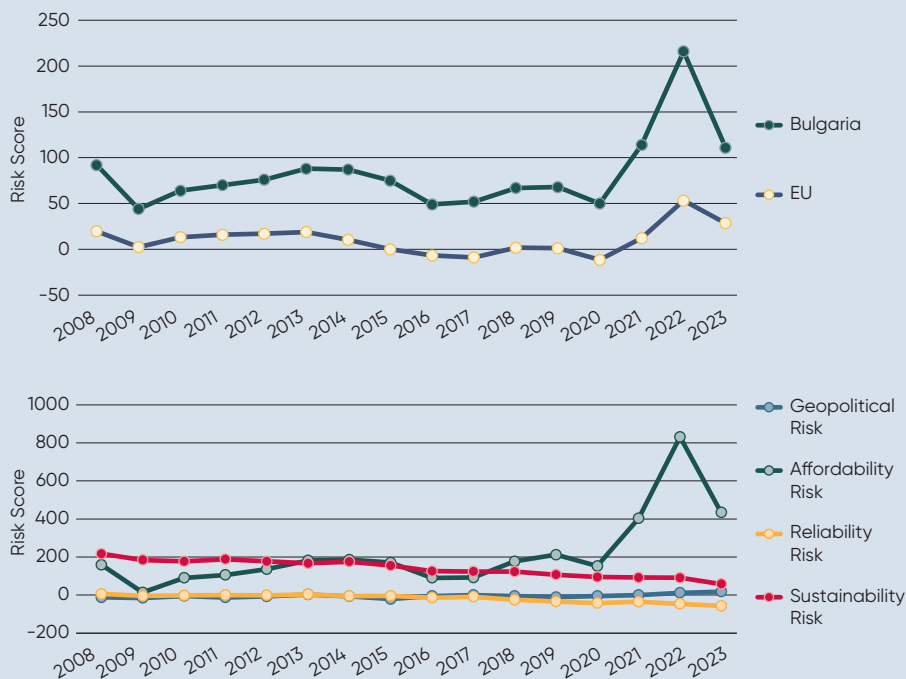
energy affordability risk increased beyond 2022 levels. Household energy prices were among the highest in the EU, reflecting both the structural cost of energy imports and the broader inflationary impact of market volatility. While Austria's clean electricity system reduces long-

term vulnerability to fossil fuel price shocks, the current energy market design and dependency on external gas flows still create price instability. This underscores the limits of even high-renewable systems in shielding consumers during a broader energy crisis.



BULGARIA

Energy Security Risk Score Summary	
2023 Energy Security Risk Score	111
Geopolitical Risk	18
Affordability Risk	434
Reliability Risk	-57
Sustainability Risk	58
ECSRI Score in 2015	75
Overall Rank	24



Bulgaria ranks second to last only behind Poland in the ECSRI, reflecting the country’s long-standing structural energy security challenges. This elevated risk profile is primarily driven by the country’s continued reliance on fossil fuels, which made up 77% of its energy mix in 2022, including 25% coal.¹⁰³ Until the end of 2023, Bulgaria also maintained a high level of fossil fuel import dependency, particularly on Russia, which used to be one of its largest energy suppliers. The situation has rapidly changed since early 2024 when Bulgaria banned the imports of Russian oil, and has stopped buying Russian nuclear fuel for its Kozloduy power plant.

However, the country has continued indirectly importing Russian gas via virtual swap agreements with Greek traders with long-term contracts with Gazprom. The country has also become the single largest Russian gas transit hub in Europe as TurkStream flows passing through Bulgaria’s gas transmission network are reaching record levels of around 18-19 bcm/yr. If Europe is to complete its decoupling from Russian energy dependence by the end of 2027, Bulgaria would play a leading role in cutting the gas transit, which is protected by a 20-year ship-or-pay contract with Gazprom.

On the sustainability front, Bulgaria has been slow to implement an all-economy shift to renewables, as only around 20% of its energy supply comes from renewables (which also include a disproportionately high use of firewood for heating) – well below the EU’s 2030 target of 42.5%. Yet, the energy crisis and the surging power prices have significantly pushed up investments in solar PV plants and battery storage. The result is that by the end of 2025 Bulgaria would likely have around 4 GW of installed PV and close to 1500 MWh of storage capacity. However, the inconsistent regulatory framework, the slow permitting and grid connection processes and the social backlash have torpedoed at least 5 GW worth of onshore wind energy projects that could reduce the need for coal-based balancing in peak demand periods. Unlike Poland and Romania, Bulgaria has also failed to introduce a special offshore wind energy law that will create an enabling regulatory environment for unlocking the enormous potential of the Black Sea, estimated at 116 GW¹⁰⁴.

The uneven energy transition process has left the country vulnerable to carbon pricing policies under the EU ETS. As carbon prices surged after 2018, Bulgaria’s

¹⁰³ Vladimirov, M. et al., *Decarbonising the Bulgarian Power Sector: Resolving the Coal Phase-Out – Security of Supply Conundrum*, Sofia: Center for the Study of Democracy, 2023.

¹⁰⁴ Trifonova, M., and Vladimirov, M., *Wind Power Generation in Bulgaria: Assessment of the Black Sea Offshore Potential*, Sofia: Center for the Study of Democracy, 2021.

emissions- and energy-intensive economy—which still relies heavily on coal—was hit particularly hard. The country’s CO₂ costs per GDP are alongside Poland, Czechia, Estonia, and Greece among the highest in the EU. The carbon costs are expected to rise further as the free emissions allowances are phased out between 2026 and 2034 under the expanded EU ETS II, which will cover sectors like buildings and road transport with no free allocations.

Bulgaria also faces mounting affordability risks even as household electricity consumers remain shielded by regulated tariffs and the stable fiscal position of the country has allowed the disbursements of billions in subsidies to industrial energy consumers. The low GDP per capita coupled with the lowest

energy efficiency levels in Europe has meant that even subsidized prices cannot reduce energy poverty significantly. Around a fifth of Bulgarian households are considered energy poor, a level that has come down from around 40% a decade ago, but is still the highest in the EU.

Like Poland and Romania, Bulgaria’s economy remains excessively dependent on raw material extraction, and energy-intensive industries, sectors that are both hard to decarbonize and sensitive to energy price volatility. These industries currently benefit from free emissions allowances under the EU ETS, but the gradual phase-out of this support threatens their future competitiveness unless Bulgaria can transition to cleaner, more efficient technologies.

ANNEX 2. ECSRI RANKING

Table 1. Ranked Risk Values for 2023 (the latest year with full available data).

Ranking of the EU countries across four key dimensions: Geopolitical, Affordability, Reliability, and Sustainability. The benchmark value is the EU average score for 2015, taken as zero, against which countries compare in the different categories. Lower values indicate lower levels of risk. Negative values indicate improvement from the benchmark and positive values worsening.

Geopolitical Risk	Affordability Risk	Reliability Risk	Sustainability Risk	Energy & Climate Security Risk (Overall)
1.Estonia (-102.9)	1.Luxembourg (-48.4)	1.Slovakia (-199.4)	1.France (-102.8)	1.France (-27.6)
2. Finland (-101.6)	2. Finland (2.5)	2. Latvia (-143.9)	2. Netherlands (-100.1)	2. Austria (-18.4)
3. Denmark (-87.8)	3. Sweden (29.2)	3. Slovenia (-118.7)	3. Italy (-82.0)	3. Denmark (-14.7)
4. Sweden (-72.3)	4. France (50.0)	4. Austria (-115.0)	4. Belgium (-73.7)	4. Sweden (-14.5)
5. Netherlands (-49.2)	5. Denmark (59.6)	5. Czechia (-59.8)	5. Austria (-70.0)	5. Slovakia (-13.6)
6. Germany (-47.5)	6. Ireland (63.5)	6. Bulgaria (-56.7)	6. Spain (-65.7)	6. Spain (-2.3)
7. Romania (-47.0)	7. Spain (101.7)	7. Romania (-42.4)	7. Germany (-54.0)	7. Latvia (-1.5)
8. France (-45.6)	8. Austria (103.1)	8. Spain (-36.4)	8. Slovakia (-49.7)	8. Luxembourg (2.75)
9. Croatia (-28.2)	9. Portugal (120.1)	9. Hungary (-33.7)	9. Sweden (-49.2)	9. Netherlands (5.6)
10. Poland (-26.8)	10. Belgium (125.9)	10. Netherlands (-32.4)	10. Portugal (-44.1)	10. Finland (5.7)
11. Latvia (-25.1)	11. Slovakia (151.6)	11. Germany (-31.2)	11. Croatia (-40.5)	11. Germany (7.6)
12. Slovenia (-17.8)	12. Germany (165.1)	12. Greece (-25.4)	12. Ireland (-24.3)	12. Slovenia (15.4)
13. Luxembourg (-14.0)	13. Hungary (173.8)	13. Estonia (-16.3)	13. Slovenia (-19.9)	13. Portugal (18.0)
14. Spain (-7.0)	14. Latvia (183.0)	14. Italy (-13.9)	14. Denmark (-17.9)	14. Ireland (20.5)
15. Portugal (-6.4)	15. Romania (189.3)	15. Denmark (-12.2)	15. Latvia (-17.3)	15. Estonia (28.9)
16. Czechia (-5.0)	16. Estonia (191.2)	16. France (-11.4)	16. Greece (-16.9)	16. Romania (33.7)
17. Lithuania (-0.8)	17. Netherlands (207.2)	17. Lithuania (0.9)	17. Czechia (-16.3)	17. Belgium (40.5)
18. Ireland (5.7)	18. Italy (218.3)	18. Portugal (3.5)	18. Luxembourg (-10.7)	18. Italy (40.5)
19. Austria (9.4)	19. Slovenia (221.5)	19. Belgium (6.8)	19. Lithuania (5.1)	19. Croatia (48.0)
20. Bulgaria (17.7)	20. Croatia (222.4)	20. Sweden (34.7)	20. Hungary (6.9)	20. Hungary (53.0)
21. Italy (42.2)	21. Greece (260.6)	21. Ireland (37.3)	21. Romania (36.9)	21. Lithuania (66.0)
22. Slovakia (46.1)	22. Lithuania (261.3)	22. Croatia (40.3)	22. Poland (38.7)	22. Czechia (71.2)
23. Hungary (66.1)	23. Czechia (372.3)	23. Finland (40.9)	23. Estonia (46.0)	23. Greece (75.7)
24. Greece (87.3)	24. Bulgaria (433.6)	24. Poland (43.0)	24. Bulgaria (57.8)	24. Bulgaria (111.3)
25. Belgium (104.3)	25. Poland (459.9)	25. Luxembourg (83.7)	25. Finland (81.8)	25. Poland (126.8)

