



# Towards sustainable energy security

Europe needs a new strategy now

Forum Energii is a European, interdisciplinary think-tank from Poland, whose team consists of experts working in the field of energy. We combine experience gained in, among others, public administration, business, science and media.

The mission of Forum Energii is to initiate dialogue, propose knowledge-based solutions, and inspire action for a just and efficient energy transition paving the way towards climate neutrality. We attain this goal through analysis, opinions and discussion on decarbonisation of major branches of the economy. All of the Forum Energii's analyses may be reproduced provided their source and authors are indicated.

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#### PUBLICATION DATE:

March 2025

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## Process and acknowledgments

This report is a result of several months of joint collaboration among analysts from three European think tanks: Forum Energii, Bruegel, and the European Council on Foreign Relations (ECFR). It was prepared by the team of Maciej Jakubik (lead and editor) and Maciej Zaniewicz (Forum Energii), Georg Zachmann, and Ugne Keliauskaite (Bruegel), and Szymon Kardaś (ECFR).

The focus of this work is addressing the emerging challenges related to energy security in the context of geopolitical tensions, technological advancements, and climate constraints. Additionally, the European Commission's announcement of a revision to the EU's energy security architecture, along with Poland's decision to prioritise energy security during its Presidency of the Council, provided further impetus for our work.

The research for this report involved organising a series of in-depth discussions with policymakers and industry experts through four workshops held in Warsaw, Brussels, Berlin, and Kyiv between October 2024 and January 2025. We thank the participants for their active involvement and opinions which we took as an important input for this paper.

Senior government representatives and international organisation experts also contributed and provided inspiration to this report. We would like to thank in particular officials from DG Energy of the European Commission, NATO's Climate and Energy Security Section, Ministry of Climate and Environment of Poland, Office of the Prime Minister of Poland, Ministry of Economy and Climate of Germany.

We would like to extend our gratitude for the valuable comments and feedback on the preliminary draft of this report provided by Jacques Warichet and Miłosz Karpiński from the International Energy Agency (IEA), Marco Giuli (Agora Industry), and Christian Egenhofer (CEPS). Their insights and suggestions were highly valuable.

2 Moreover, several experts were consulted on an individual basis, and we would like to extend our appreciation to them: Artur Swietanowski, Olena Pavlenko, Frank Umbach, Yana Popkostova, Marc Antione Eyl-Mazzega.

The opinions and judgments expressed in this report are solely those of the authors and do not reflect the institutions, nor any colleagues that kindly provided input.

# Executive Summary

Energy security in Europe has been shaped by the availability and affordability of fossil fuels, which have underpinned economic growth. Although this will continue for some time but their role in driving Europe’s economies will gradually diminish. At the same time, electrification based on renewable energy sources (RES) will further expand and cover more and more sectors, including electric vehicles (EVs), heating, home appliances, industry, and agriculture. While the European Union’s energy security policies have evolved in response to geopolitical and climate challenges, the European Energy Security Strategy from 2014 was adopted under different circumstances and no longer reflects the change of priorities that have shaped EU energy systems in the last decade.

## A new paradigm

One can observe three major shifts in circumstances that call for a new energy security paradigm:

- 1** **First, the energy transition brings new promises and perils.** Domestically produced electricity is foreseen to become the main pillar of EU energy supply in the coming decades. This will gradually resolve the vulnerability to energy imports, but new challenges related to variability are arising;
- 2** **Second, the lessons from the energy crisis** which drastically exposed critical weaknesses in the EU’s energy system, such as over-reliance on a single supplier, clustered technology risks, and climate-change impacts;
- 3** **Third, new geopolitical headwinds** which are reshaping global politics: the Russian aggression against Ukraine, the rivalry between the US and China, the likelihood of trade wars, and the ongoing technology race. European energy security is under serious pressure.

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## New energy security pillars

The EU faces a dual challenge: ensuring energy security while accelerating its transition to sustainable energy. A modernised approach to energy security is urgently needed. This new approach must embrace

<p><b>Multidimensionality</b></p> <p>Integrating security within trade, defence, climate and environmental policies.</p>	<p><b>Collectiveness</b></p> <p>Ensuring greater EU-wide cooperation.</p>
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## New EU sustainable energy security strategy urgently needed

In this text, **we propose to launch an urgent political discussion on a new European sustainable energy security strategy** that would constitute the basis for the future energy security architecture in the EU. Its essence should be integrity, both in terms of the material scope of action (multidimensionality, that is, embedding security in various national and EU policies) and a toolbox of action based on greater collective action (solidarity, interconnections). The new strategy should evolve to encompass the diverse factors and policies that form modern energy security dimensions.

## A revised definition of energy security

*Sustainable energy security is the ability of a flexible and resilient energy system to reliably provide sustainable and accessible energy services, critical minerals and technologies, while also adapting to evolving challenges related to climate change and environmental constraints, as well as cyber threats, without unduly burdening consumers.*

## Main elements of the strategy

**Ensuring the security of energy supply** in the context of a tense global security situation during the energy transition is crucial. It must be **combined with climate and environmental protection** as a long-term goal. The strategy should be implemented consistently, step by step. While a slower pace can be considered, changing course is not an option.

- **Zero- and low-emission sources, flexibility and grids**

The strategy should evolve to ensure **the unrestricted deployment of renewable generation, other zero-emission and flexible sources, and the reliable development and functioning of electricity grids**. It must address energy system flexibility, energy efficiency, and controlled demand reduction, which are of utmost importance to rationalise energy use and manage costs. Thus, it must reflect a more comprehensive understanding of the factors that can impact today's energy system security.
- **Better integration and coordination within the EU**

Ensuring **high interconnectivity** between EU member states is essential for enhancing the security of energy supply and enabling the effective integration of energy markets across the continent. Better integration is also a contributing factor to lowering energy prices in the EU.

The strategy should promote enhanced cross-border energy infrastructure to reflect the reality of EU countries' **increasingly interconnected and interdependent energy systems. More cooperation between EU member states and greater responsibility at the EU level is necessary**, complementing national efforts. The European Commission can play a pivotal role by coordinating energy security dimensions in the NECPs and national policies, ensuring coherent policies in risk preparedness areas and planning. Establishing a **dedicated EU Energy Agency** to facilitate **joint pan-European integrated planning** for net-zero infrastructure and centralised data collection could enhance policy coherence.
- **Solidarity and resilience as a core principles**

A renewed emphasis on the **principle of solidarity** among EU member states is crucial to fostering collective responses to energy crises and developing a legally binding solidarity mechanism agreement to ensure rapid assistance in case of shortages and emergencies. This underscores the **importance of resilience**, which addresses the ability of energy systems to withstand diverse and uncertain threats.
- **Protection of energy infrastructure**

**Critical infrastructure protection** and a need to improve its resilience from emerging threats, unconventional attacks, and other risks emerge as a priority in view of recent incidents. It should also include **coordinated strategies for cybersecurity and IT resilience** for safeguarding critical energy infrastructure in the digital era. Maritime security should be strengthened, in close cooperation with NATO and allied nations to monitor and protect sea-based energy infrastructure and supply routes.

- **Diversification of supply of fuels, minerals, and technologies**

The strategy should address both the **diversification of energy resources and the development of resilient supply chains for critical materials and technologies**. Joint aggregation platforms can constitute an important element of the EU strategy to ensure sufficient supplies at favourable prices. EU trade policy instruments should play a greater role and expand trade partnerships through “friendshoring,” prioritising reliable partners sharing similar values over adversarial nations.

When shifting toward renewable energy, the **EU must prioritise the phase-out of Russian fossil fuels from its energy mix**. If a complete ban is not feasible, a strategy for gradually reducing of Russian fossil fuels must be implemented. By ending its reliance on Russian energy imports, the EU not only reduces geopolitical risks but also drives sustainable growth and meets political and climate objectives.

- **Investments in technologies and the development of clean industrial policies**

Investing in **clean technologies** strengthens the EU’s sustainable energy security by reducing reliance on external suppliers and enhancing system resilience. Smart grids, AI-driven energy management, hydrogen, and nuclear projects improve efficiency and stability. Aligning energy and industrial policies supports a strong renewable supply chain, cutting external dependencies.

- **Improved energy diplomacy**

A **strong energy diplomacy** is key to the EU’s sustainable energy security, ensuring stable, diversified partnerships. As a major market, the EU should prioritise trade with candidate countries like Ukraine, Moldova and Western Balkans, offering incentives for clean energy cooperation. Democratic allies should receive reciprocal trade benefits, while rivals like Russia and China face scrutiny and tariffs. Aligning diplomacy with climate and economic goals can strengthens EU energy resilience.

**A new EU sustainable energy security strategy must be adopted without delay.** By integrating sustainability, resilience, multidimensionality, and collectiveness, the EU can ensure energy autonomy, stability, and long-term prosperity. The time to act is now—Europe’s energy future depends on bold leadership and strategic decisions.

## Chapter 1.

### Introduction. Three trends driving a re-evaluation of EU energy security

Energy has been a cornerstone of economic development throughout history, shaping how societies produce, trade, and grow. Since the industrial revolution, access to affordable, and reliable energy has been critical for economic growth and technological innovation, driving unprecedented expansion in developed nations. With the increasing consumption of energy and greater dependence of the economies and societies on it, stable supplies of energy resources are crucial to a nation's development.

For much of the past, energy security was not a highly topical issue for policymakers or business. That changed at the beginning of the 20<sup>th</sup> century as industrialisation and the global reliance on oil and coal grew rapidly. It gained significant geopolitical importance first during World Wars I and II when securing fuel for military operations was critical, and then in the 1970s when global oil crises marked a pivotal moment in the modern discourse on energy security, exposing the vulnerabilities of oil-dependent economies. These events triggered governments to prioritise energy diversification, establish strategic reserves, and set up energy security strategies.

Energy security also intersected with the political dynamics, geopolitical situation, and alliances on the global stage. Oil and gas producers used it as leverage over countries poor in energy resources. Changing coalitions and fluctuations in patterns of trade and commodities are still basic features of the oil and gas industry. Now, this picture is shifting again.

#### 1.1. The energy transition is profoundly reshaping dependencies and vulnerabilities

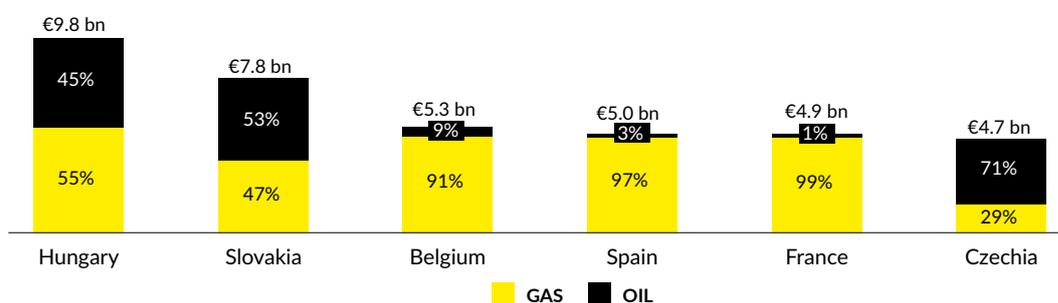
6 In recent years, energy systems have been experiencing significant changes with the expansion of renewables, gradual decline of fossil fuel-based generation, the use of new digital and innovative technologies, as well as the development of distributed energy. All these factors are changing the perception and very nature of energy systems and also impact trade and geopolitical patterns.

Yet, the concept of energy security has consistently been tied to fossil fuel supplies. Although they still are important and will continue to be in the coming years, their role in driving our economies will gradually diminish. At the same time, electrification will further expand and cover more and more sectors, including electric vehicles (EVs), heating and cooling, home appliances, data centres, industry use, and agriculture. This has a tremendous impact on our daily life and the energy system, requiring new approaches and solutions to tackle the challenges of daily operations, system management, and need for increased resilience. This change of approach and priorities also should be reflected in policy documents and strategies.

#### 1.2. Energy crisis: exposing EU energy weaknesses, revealing solutions

The recent energy crisis in Europe has highlighted the urgent need to rethink an approach to energy security. Driven by geopolitical tensions, supply shortages, and soaring prices, the crisis exposed critical vulnerabilities, including an over-reliance on a narrow range of energy sources and few external suppliers. These weaknesses come with substantial costs, not only economically but also in terms of increased political risks, with several countries continuing to depend on or profit from Russian imports (Figure 1). This reliance on Russia in particular has led to a hesitance in imposing sanctions on gas imports from that country. To build resilience and better prepare for future disruptions, it is crucial to identify critical factors that will help effectively manage energy crises in the future.

Figure 1: Expenditure on Russian gas and oil imports by largest importers, 2023-2025 (to February 1), billions EUR.



Note: in total, the EU spent €55.5 bn on imports of Russian gas (66%) and oil (34%) 2023-2025 (to February 1).

Source: Bruegel on CREA.

### Key takeaways from the energy crisis

The assessment of energy security risk in the EU has been primarily focused on identifying the critical impacts of isolated events, such as losing the most important power plants, transmission lines, or gas pipelines (N-1 criteria for risk assessment). This means systemic risks have been largely overlooked. Dependencies on single suppliers or technologies, interdependencies of energy sources (generating electricity from gas, nuclear, hydro), cross-border spillover, and low-probability high-impact events (extreme weather or geopolitical tension) have been largely neglected.

- **Enhancing risk awareness:** More transparent and comprehensive data collection on energy dependencies is the critical first step to identifying and effectively liquidating energy security risks. This assessment on dependencies related to energy imports should be conducted at the European level.
- **Strengthening preparedness:** Tools to encourage diversification of energy sources need to be effective. Additionally, tools to maintain some security margin in terms of reserve capacity and infrastructure should be coordinated on the European level.
- **Responding effectively in a crisis:** Governments should be better able to put administrative resources on critical issues. Moreover, in a supply crisis, better tools should be applied to decrease energy usage in sectors with the lowest economic or social benefit (“low-value energy demand”) in order to reduce the harm of the crisis on society or the broader economy.
- **Learning from a crisis:** Clear and independent assessment of lessons learnt from successes and failures is needed. Corresponding data should be shared with academia to learn from such unique “natural experiments”.

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### 1.3. Geopolitical shifts force a fresh look at old and new dependencies

Global politics have forced unprecedented geopolitical turbulence, reshaping supply chains, investment flows, and strategic alliances. Russia’s ongoing aggression against Ukraine has profoundly disrupted global energy markets, leading to interruptions, sanctions, reconfiguration of gas and oil supply routes, and intensified energy diversification efforts, particularly in Europe. Simultaneously, the strategic competition between the United States and China is accelerating, with energy security, critical minerals, and technological dominance at the core of this rivalry. Trade tensions and protectionist policies are exacerbating supply chain vulnerabilities, particularly in clean energy technologies, where dependencies on specific regions remain high.

Geopolitical instability has heightened concerns over energy security, prompting nations to reassess their reliance on single suppliers and vulnerable supply routes. EU countries are accelerating efforts to diversify energy sources, invest in domestic production, and strengthen strategic reserves to mitigate risks. This shift is driving a surge in renewable energy investments and regional cooperation while also reshaping global energy alliances. Moreover, the new U.S. administration’s shift to a more transactional and assertive approach could have serious implications for the future fate of energy and security cooperation in the transatlantic area.

## Chapter 2.

### Energy Security: A diverse set of definitions within evolving legal frameworks

#### 2.1. Most common energy security definitions and concepts

Numerous definitions of energy security have been proposed, based on different methods drawn from economics, political science, and engineering. The concept of energy security is widely recognised as context-dependent, with its meaning varying across countries and situations. However, there has been limited attention given to the concept of energy security within the context of future low-carbon energy systems. An overview of existing definitions of energy security is essential for understanding the foundations of the current approach and its evolution over time. However, many experts and institutions have already signalled the need for a new framework that reflects the emerging challenges, including geopolitical shifts, supply diversification, and the green transition<sup>1</sup>.

The material scope of energy security used to be discussed mainly in two dimensions: “physical” and “economic”. The first one concerns the availability and reliability of energy resources and infrastructure. It focuses on ensuring a stable and uninterrupted supply to meet current and future demands. The economic dimension focuses on the affordability of energy and the economic stability of energy markets. It considers the financial impacts of energy availability on consumers, businesses, and national economies<sup>2</sup>. This is how Daniel Yergin summarised it: “availability of sufficient supplies at affordable prices”<sup>3</sup>.

Authors from Asia Pacific Energy Research Centre<sup>4</sup>, focused on different features of energy security studying what the notion encompasses and they proposed four “As” of energy security: availability, accessibility, affordability and acceptability. This approach tends to expand the notion of energy security however it inclines to describe divers features of the concept and not to provide a holistic overview of a meaning of energy security.

This is also evidenced by the existing definitions of energy security, which mostly focus on the security of fuel supply and affordability.

Table 1. Typical definitions of energy security

Author	Definition
IEA	“uninterrupted availability of energy sources at an affordable price” <sup>5</sup>
OSCE	“having stable access to energy sources on a timely, sustainable and affordable basis”
United Nations	“access to affordable, reliable, sustainable, and modern energy for all”
European Commission	“uninterrupted physical availability of energy products on the market at a price affordable for all consumers” <sup>6</sup>

There also have been attempts to define energy security as a property of energy systems in terms of their vulnerability to various risks that change with time and place. These definitions identify four key aspects: stability (the ability to cope with internal shocks, e.g., infrastructure failure), resilience (the ability to deal with external shocks, e.g., supply disruptions), durability (the ability to cope with long-term internal stresses, e.g., increased demand), and robustness (the ability to cope with long-term external stresses, e.g., resource depletion).<sup>7</sup>

1 For a discussion of definitions please check: [https://discovery.ucl.ac.uk/id/eprint/10087004/6/Dodds\\_IMPJ5213-H2FC-Supergen-Energy-Security-032017-Chapter%202.pdf](https://discovery.ucl.ac.uk/id/eprint/10087004/6/Dodds_IMPJ5213-H2FC-Supergen-Energy-Security-032017-Chapter%202.pdf)

2 Global Energy Assessment. Toward a Sustainable Future. Chapter 5: Energy and Security, Cambridge, 2012. [https://www.researchgate.net/publication/266738121\\_Chapter\\_5\\_-\\_Energy\\_and\\_Security](https://www.researchgate.net/publication/266738121_Chapter_5_-_Energy_and_Security)

3 Daniel Yergin Ensuring Energy Security, Foreign Affairs, Vol. 85 No 2, 2006 <https://www.jstor.org/stable/20031912?origin=crossref>

4 The concept of energy security Beyond the four As; A Quest for Energy Security in the 21st Century (2007) ([aperc.or.jp](http://aperc.or.jp))

5 Compare: <https://www.iea.org/topics/energy-security>

6 European Commission. Green Paper—Towards a European strategy for the security of energy supply. 2000. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52000DC0769>

7 Dodds\_IMPJ5213-H2FC-Supergen-Energy-Security-032017-Chapter 2.pdf ([ucl.ac.uk](https://discovery.ucl.ac.uk))

Currently, in the **era of renewable energy**, energy security is increasingly defined by availability, accessibility, and resilience, emphasising technology, infrastructure, and system stability beyond traditional fuel supply. This is already reflected in the approach to energy security in some states, international organisations, and expert circles.

**In terms of countries**, the UK parliament lists “environmental and geopolitical acceptability” among important elements of energy security<sup>8</sup>. Further, the UK Government’s Energy Security Strategy treats physical security and price security as part of energy security. In US official documents, special focus is put on infrastructure that is protected against physical and cyber threats<sup>9</sup>. Poland, in its Energy Law, mentions the requirements of environmental protection as part of the energy security concept<sup>10</sup>.

**Among international organisations**, IRENA, for instance, highlights the need for multi-dimensional options in the regulation of energy security. “Reflexively transposing the geopolitical considerations of the fossil fuel era to the era of renewable energy could lead to significant oversights and ill-considered investments”<sup>11</sup>.

The **IMF’s** analysis connects energy security with the green transition and how reducing reliance on fossil fuels can introduce new challenges while also offering opportunities for improved energy security through diversification and innovation. The research indicates that meeting emission-reduction targets could improve energy security. This improvement is attributed to enhanced domestic energy production and reduced reliance on imported fossil fuels, which are often subject to geopolitical risks and market volatility. The current green transition aims to promote the diversification of energy sources through renewable energy investments.

Expert circles are even more ambitious in shaping the new approach to energy security. Some authors claim that “a more comprehensive and coherent strategy is urgently needed that integrates energy security with the imperative to tackle climate change”<sup>12</sup>. They propose that the concept focus on: reduction of energy demand, introduction of social tariffs to shield the most vulnerable, rapid deployment of non-fossil energy sources, strategy for a skills transition in the supply chain and risks associated with the legacy fossil fuel energy system, and emerging risks associated with critical materials, digitalisation and interconnection.

One approach that goes beyond assessing the likelihood and impact of shocks to the energy system is the concept of energy system resilience<sup>13</sup>. It refers to the capacity of an energy system to anticipate, withstand, and rapidly recover from disruptions. It involves the ability to absorb or limit the impact of such disruptions and transform where necessary to ensure continuous energy supply and functionality.

## 2.2. EU energy security framework: powerful measures, but no cohesive strategy

The European Union’s approach to energy security has evolved significantly in response to geopolitical and climate challenges, as well as changing political, technical, and economic needs. While coal supply concerns that led to the creation of the European Coal and Steel Community in the 1950s were short-lived, energy security became a focus with the 1970s oil crisis, prompting efforts to diversify energy sources and improve energy efficiency. Member states prioritised reducing dependence on oil through nuclear power development and later policies supporting renewable energy.

Market liberalisation in the 2000s and the development of cross-border energy infrastructure, also undersea cables and pipelines, consolidated the internal energy market and led to a significant increase in trade in electricity and gas.

The EU’s exposure to Russian natural gas imports was highlighted during the 2006 and 2009 Ukraine-Russia gas disputes, which disrupted supplies to Europe. In response, the EU proposed the Energy Security and Solidarity Action Plan in 2009<sup>14</sup>, which aimed at reducing energy consumption by almost 15% and energy imports by 26% by 2020.

8 Energy security (parliament.uk), <https://researchbriefings.files.parliament.uk/documents/POST-PN-0676/POST-PN-0676.pdf>

9 Energy Independence and Security, Department of Energy, <https://www.energy.gov/eere/energy-independence-and-security>

10 Prawo Energetyczne, art. 3(16), <https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=wdu19970540348>

11 Geopolitics of the energy transition: Energy security (irena.org) IRENA, 2024.

12 Jim Watson, Cathy Page. Energy Security: A Sustainable Strategy for the UK, UCL 2023. [https://www.ucl.ac.uk/bartlett/sustainable/sites/bartlett\\_sustainable/files/isr\\_141123\\_energy\\_security\\_-\\_a\\_sustainable\\_strategy\\_for\\_the\\_uk.pdf](https://www.ucl.ac.uk/bartlett/sustainable/sites/bartlett_sustainable/files/isr_141123_energy_security_-_a_sustainable_strategy_for_the_uk.pdf)

13 Find more on resilience at NREL: <https://www2.nrel.gov/security-resilience/energy-resilience>

14 <https://eur-lex.europa.eu/EN/legal-content/summary/energy-security-and-solidarity-action-plan.html>

After Russia's annexation of Crimea and the beginning of the war in Donbas, concerns over gas and oil supplies from Russia grew significantly. The EU responded by drafting the European Energy Security Strategy in 2014 and establishing the Energy Union in 2015 in an attempt to integrate energy security with climate goals and market integration, focusing on renewables, energy efficiency, and reducing dependency on imports. Despite these documents, reliance on Russian gas imports continued to grow over time, culminating in the construction of the Nord Stream pipelines. Only the 2022 Russian full-scale invasion of Ukraine accelerated the EU's shift away from Russian energy, with RePowerEU Plan primarily aimed at phasing out Russian fossil fuel imports by 2027 at the latest (although this is a legally non-binding target).

Overall, the EU has developed a framework of policies, documents, and legal acts to address energy security. However, it is important to bear in mind that energy policy is a shared competency, with EU institutions holding only partial responsibility, while most of it lies with the member states.

- ### European Energy Security Strategy

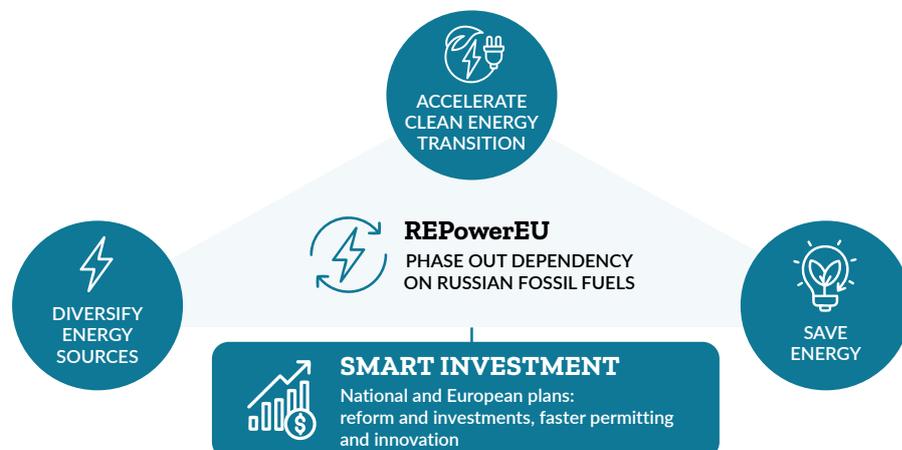
The strategy was released in May 2014 and aims to ensure a stable supply of energy for European citizens and the economy<sup>15</sup>. The document sets out areas in which decisions must be taken or concrete actions implemented to respond to energy security concerns. It is based on eight key pillars, in a mix of short and long term, which are underpinned by the principle of solidarity. It encourages member states to coordinate, plan, and diversify supplies while moderating energy demand and building a well-functioning and fully integrated internal market.

The strategy is a policy document that does not have a direct legal obligation. It provides guidance and outlines priorities for energy security across the EU. However, it was too vague and did not prompt major European or national policies that would have been necessary to prevent or mitigate the 2022/23 energy crisis.

- ### RePowerEU

In response to the full-scale Russian military aggression against Ukraine, the RePowerEU plan was proposed by the Commission in May 2022<sup>16</sup>. It sets a legally non-binding target to eliminate the EU's reliance on Russian fossil fuels by 2027 by diversifying natural gas supplies via imports from reliable partners, as well as LNG and biomethane production.

It aims at reducing energy demand through efficiency improvements and behavioural changes, and at increasing the share of renewables, with a target of ideally 45% by 2030. It also seeks to boost green hydrogen production and imports to decarbonise hard-to-abate sectors.



<sup>15</sup> <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52014DC0330>

<sup>16</sup> <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A230%3AFIN>

The EU also established a package of legislation that creates a binding framework of energy security for member states and energy companies.

#### • Security of Gas Supply Regulation

The Security of Gas Supply (SoS) Regulation, last revised in June 2022, addresses key issues related to uninterrupted gas supplies and sets up cooperation in the event of crises<sup>17</sup>. One of its main objectives is to enhance EU emergency preparedness and resilience to gas disruptions. This includes an early warning system and the Gas Coordination Group to assess and discuss security-of-supply issues. ENTSO-G is tasked with preparing seasonal outlooks that forecast the situation with supply over the coming months. The regulation provides for a catalogue of measures in the event of a supply crisis and obliges member states to define the framework of prevention and contingency procedures and crisis management, including preventive measures.

A key element of the SoS Regulation is the strengthening of risk-related cooperation between member states. Risk groups are defined and they serve as a basis for enhanced regional cooperation and allow for the agreement of appropriate cross-border measures<sup>18</sup>.

Another key element is the principle of solidarity, according to which member states are obliged to take concrete measures to ensure supply to vulnerable customers, e.g., household customers or hospitals in directly neighbouring member states, in a crisis<sup>19</sup>.

#### • Gas Storage Regulation

The Gas Storage Regulation adopted in 2022 aims to ensure sufficient gas storage ahead of winter to mitigate supply disruptions<sup>20</sup>. The regulation sets a target to ensure that EU gas storage facilities are at least 90% full by 1 December. The Commission adopts an implementing regulation setting targets for each year. It also promotes fair burden-sharing among the member states to address disparities in storage infrastructure. The member states are required to monitor and meet minimum levels for gas storage facilities. The regulation mandates access to storage for member states without facilities.

In turn, in the electricity sector there also are some legal acts that improve the framework for security of electricity supply.

#### • Regulation of Risk Preparedness in Electricity

The Risk Preparedness in Electricity Regulation was adopted in 2019 and introduced important rules for cooperation between the member states with the aim to prevent, prepare for, and manage electricity crises<sup>21</sup>. Each country must establish a risk-preparedness plan based on regional and national electricity crisis scenarios and which consist of national, regional, and bilateral measures to prevent, prepare for, and mitigate electricity crises.

Moreover, ENTSO-E is tasked with assessing seasonal and short-term adequacy, including the probability of a transmission capacity outage, unplanned power plant outage, severe weather conditions, as well as the occurrence of a single or simultaneous electricity crises.<sup>22</sup>

The Electricity Coordination Group forms an entity for the exchange of information and coordination of expertise on security of supply in electricity, including risk-preparedness, generation adequacy, and cross-border grid stability.

<sup>17</sup> <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02017R1938-20220701>

<sup>18</sup> Security of Supply | ENTSOG, <https://www.entsog.eu/security-supply>

<sup>19</sup> Legal Framework for Security of Gas Supply - FNB Gas (fnb-gas.de)

<sup>20</sup> <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32022R1032>

<sup>21</sup> <https://eur-lex.europa.eu/eli/reg/2019/941/oj/eng>

<sup>22</sup> Risk preparedness | [www.acer.europa.eu](http://www.acer.europa.eu)

- Network Codes and Guidelines**

The EU also has developed a number of legal acts that apply to system operators and energy companies that establish rules for the operation, planning, and development of the electricity and gas grid across the EU. They aim to enhance the integration of electricity and gas markets and improve the security of supply.

In particular, the Network Code on Emergency and Restoration (NC ER) specifically sets rules to ensure the reliable and coordinated restoration of the electricity grid during and after emergencies. Its main task is to develop and implement emergency plans by introducing blackout and restoration procedures, defining the processes for managing blackouts or isolated grid operation. TSOs are required to design system defence plans that identify measures to prevent emergencies, such as automatic load-shedding mechanisms in coordination with neighbouring operators.

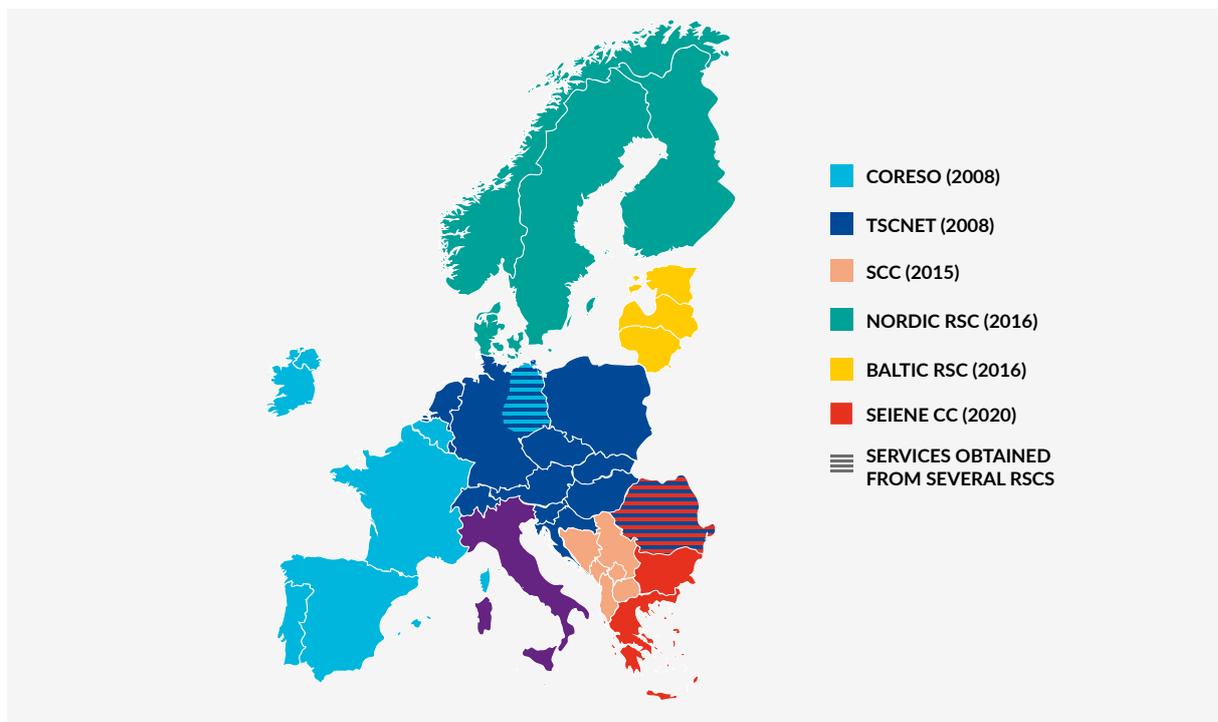
- Regional Coordination Centres (RCC)**

RCCs are strategic entities established to enhance the coordination and operation of TSOs in electricity<sup>23</sup>. RCCs perform several critical tasks that contribute to the secure operation of the electricity system. RCCs facilitate collaboration among TSOs, ensuring that decisions regarding electricity flows and grid management are made with a regional perspective, thereby enhancing overall system reliability.

The establishment of RCCs significantly improves electricity security in Europe by fostering better coordination among TSOs. This allows for more effective decision-making regarding remedial actions. RCCs help mitigate risks associated with cross-border volatile electricity flows. RCCs also play a vital role in crisis management by identifying potential regional electricity crises and developing response strategies.

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Figure 2: Regional Coordination Centres (RCC).



Source: ENTSO-e

- **Oil Stocks Directive**

The Oil Stocks Directive requires the member states to maintain minimum reserves of crude oil and petroleum products to safeguard energy supply in the event of disruptions<sup>24</sup>. It ensures that the member states maintain oil stocks equivalent to at least 90 days of net imports or 61 days of domestic consumption, whichever is higher. It also provides a reliable buffer to respond to emergencies, such as supply disruptions or natural disasters, and protect the economy from oil price volatility by stabilising supply during crises.

- **Cyber security regulations**

There are also regulations that strengthen cybersecurity in the energy sector, addressing evolving threats and ensuring resilience. In particular, the NIS2 Directive adopted in 2022 sets stricter cybersecurity requirements for critical sectors, including energy. It mandates risk-management measures, incident reporting, and cooperation between EU member states. The EU Cyber Resilience Act adopted in 2024 focuses on the cybersecurity of digital products and services, ensuring that hardware and software used in critical sectors, including energy, meet strict security standards. In turn, the Cybersecurity Network Code, adopted in 2022, establishes a harmonised regulatory framework across the member states, enhancing cooperation and ensuring cybersecurity measures for operators, which are obliged to conduct regular risk assessments and implement appropriate technical and organisational measures to address identified vulnerabilities and coordinated responses. It also promotes collaboration among member states and relevant entities to tackle cross-border cybersecurity challenges effectively.

- **Critical Raw Materials Act**

The Critical Raw Materials Act (CRMA) adopted in 2023<sup>25</sup> aims to secure the EU's supply of essential raw materials needed for the green and digital transitions, reducing reliance on third countries and ensuring stable access to materials for batteries, wind turbines, and semiconductors.

The act sets 2030 targets: at least 10% of the EU's annual consumption of critical raw materials should be extracted domestically, 40% processed within the EU, 15% sourced from recycling, and no more than 65% from a single third country. It includes the Strategic Raw Materials List of 34 "critical" and 16 "strategic" materials, prioritises Strategic Projects with faster permitting and financial support, and stockpiling requirements for supply security. The act promotes international partnerships to diversify imports and circular economy measures to enhance recycling and efficiency.

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<sup>24</sup> <https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A32009L0119>

<sup>25</sup> <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX%3A32024R1252>

## Chapter 3.

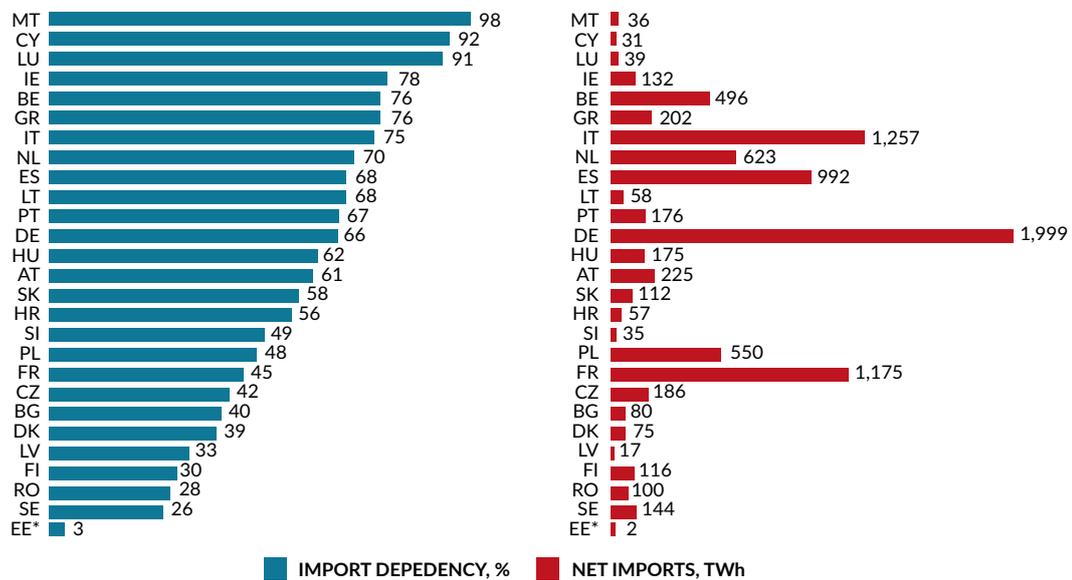
### EU energy imports and dependency decreases, but only slowly

In 2023, the EU imported slightly less than 60% of its total energy supply. More than half of these imports (62%) was oil, a third was natural gas (34%), and 4% was coal<sup>26</sup>. These numbers only change slightly when including strongly connected, close European partners, the UK, Norway, Switzerland, Western Balkans, Ukraine, and Moldova.

#### 3.1. Import dependency and import bills

All EU member states are import-dependent, especially on oil and natural gas. However, the levels of dependency vary by country. In 2023, Ireland, Belgium, Greece, Italy, and the Netherlands were over 70% reliant on energy imports, while Estonia, Sweden, and Romania had a dependency of less than 30%. (Figure 3)<sup>27</sup>.

Figure 3: Energy import dependency (left) and net energy imports (right), 2023.



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Source: Bruegel on Eurostat.

Every year, EU countries spend several hundred billion euros on imports of energy products (oil, coal, gas, coke, peat). In 2023, a cost reached more than €400 billion<sup>28</sup>.

Figure 4: EU fossil fuel imports in billions EUR, 2020-2023.

Energy product	2020	2021	2022	2023
Petroleum oil	124	194	332	275
Natural gas	39	102	313	151
Solid fuel	6	12	31	20
<b>Total EU fossil fuel imports</b>	<b>169</b>	<b>308</b>	<b>676</b>	<b>446</b>
<b>% in total extra EU imports</b>	<b>10%</b>	<b>15%</b>	<b>22%</b>	<b>18%</b>

Source: Bruegel on Eurostat.

<sup>26</sup> [https://ec.europa.eu/eurostat/databrowser/view/NRG\\_IND\\_ID\\_\\_custom\\_15229620/default/table?lang=en](https://ec.europa.eu/eurostat/databrowser/view/NRG_IND_ID__custom_15229620/default/table?lang=en)

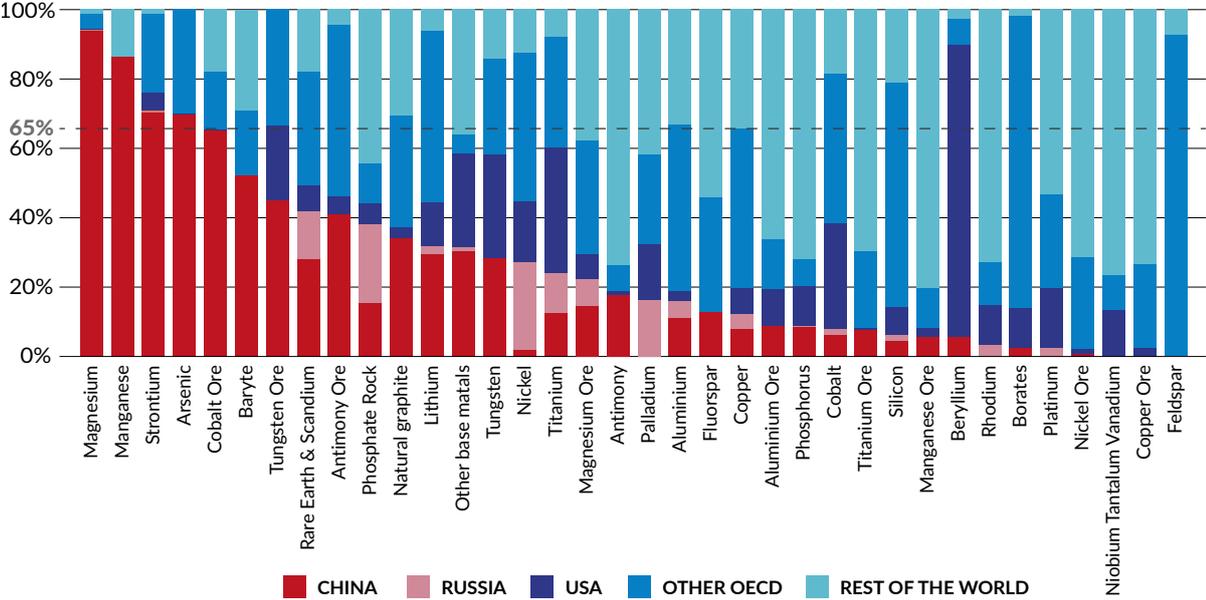
<sup>27</sup> Estonia has the lowest import dependency in the EU because its electricity generation is based on domestic oil shale (which will be gradually phased out due to high CO<sub>2</sub> emissions) but remains highly dependent on oil and gas imports.

<sup>28</sup> [https://ec.europa.eu/eurostat/statistics-explained/index.php?title=EU\\_imports\\_of\\_energy\\_products\\_-\\_latest\\_developments](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=EU_imports_of_energy_products_-_latest_developments)

Europe’s heavy reliance on fossil fuel imports creates economic vulnerability, as demonstrated by its dependence on Russian imports in the past. Despite the reduction of dependence on Russian energy in the last few years, particularly concerning oil and diesel and, to a lesser extent, gas, the risk remains that without a common EU strategy to address these dependencies, they could resurface if there’s a change in the geopolitical situation. In a world in which Europe can no longer fully depend on its powerful transatlantic partner, even previously reliable suppliers may become unstable due to the politicisation of the energy trade, while risks to international energy transport through ships or infrastructure might increase.

Beyond fossil fuels, the EU also imports other critical inputs to its energy system, ranging from various elements of the nuclear-fuel value chain (such as uranium or yellowcake), energy technologies (such as PV-panels, heat pumps, smart meters or transformers), or critical materials for domestically assembled technologies (such as neodymium magnets). The degree to which any of these imports are critical, depends on the criticality of the product itself as well as the availability of substitutes, alternative foreign or domestic suppliers, or stockpiles.

Figure 5: Origin of EU imports of critical raw materials in 2023



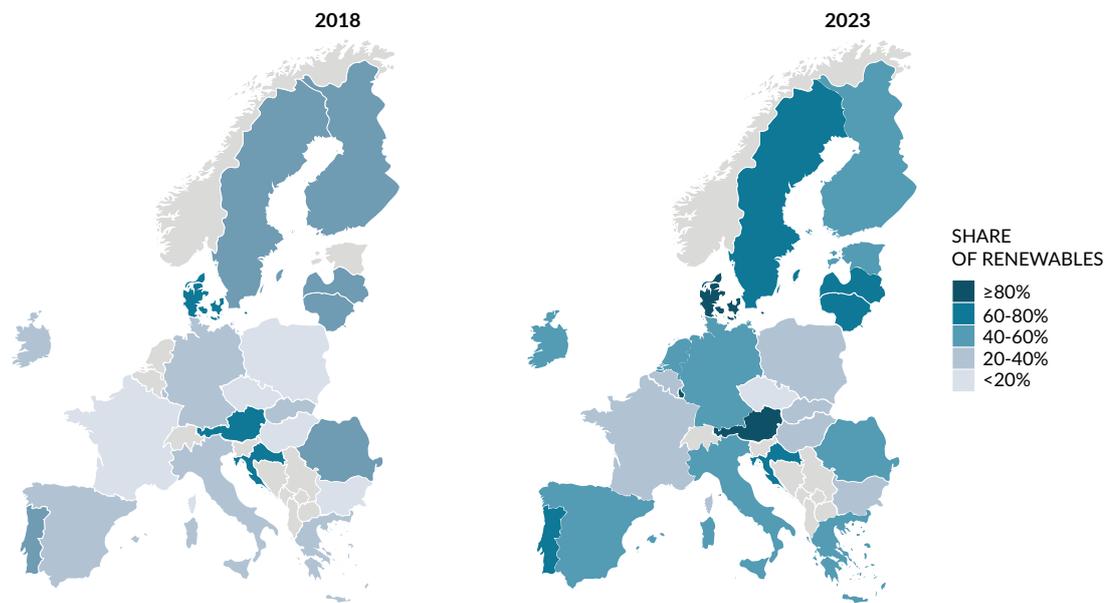
Source: [Bruegel on Eurostat](#)

More detailed figures on EU imports can be found in Annex II.

### 3.2. RES share grows and tends to increase

In the last years, the share of RES in the EU has been steadily increasing. In 2020, RES overtook fossil fuels for the first time in electricity generation, driven by coal phase-outs and favourable weather conditions for wind and hydro power. By 2023, RES made up over 40% of electricity generation, reflecting ongoing investments and technological advancements. This growth allowed substantially reduced the volume of electricity generated from natural gas and coal (Figure 6).

Figure 6: Share of renewables in electricity generation across the EU countries, 2018 and 2023.



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Source: Bruegel on Ember.

Going forward, the EU's plan is to replace imported fossil fuels for heating and transportation with domestically produced electricity. This shift would drastically increase primary energy demand, as electric transportation and heating is about three times more energy-efficient than using fossil fuels<sup>29</sup>.

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When electrification picks up, energy import dependency expressed in primary energy supplies becomes an increasingly problematic metric.

## Chapter 4.

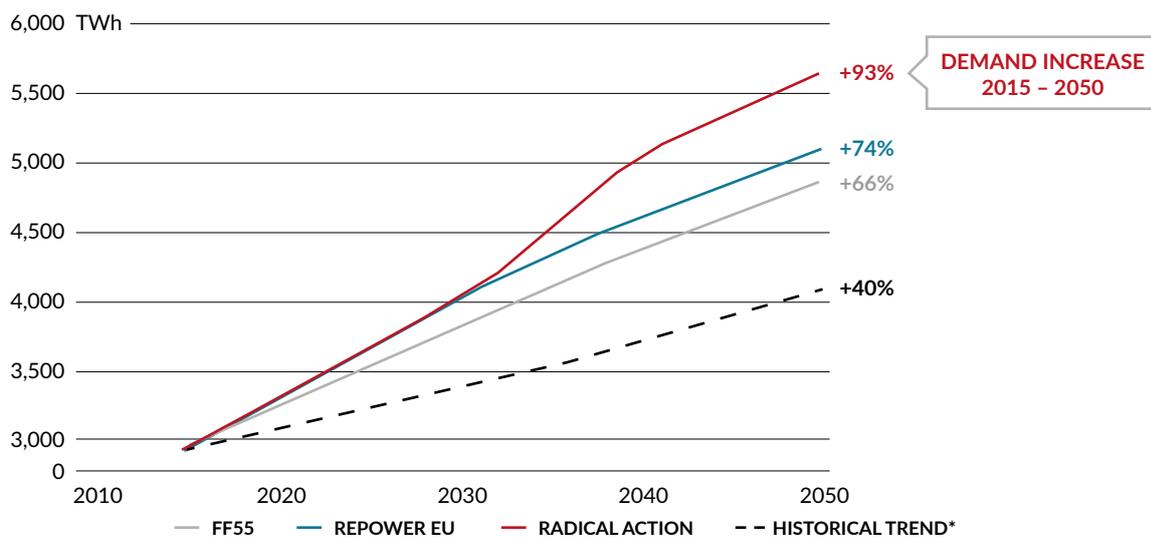
### New and evolving factors will shape the future of energy security

As the European energy landscape undergoes a transformative shift, the factors and drivers influencing energy security are also changing. The characteristics of an energy system based largely on renewables will diverge from the current one, thus its challenges and risks will have other layers. Uninterrupted energy availability will remain a crucial aspect but it will be influenced by a complex interplay of diverse and multifaceted elements.

#### 4.1. As energy demand rises, improving efficiency helps mitigate supply-security trade-offs

The energy demand trajectory is influenced by economic growth, demographic changes, and technological advancements. By 2050, Europe is expected to see a significant increase in electricity demand not only due to economic growth but also because of the electrification of transport, industry, and heating systems. According to the IEA, global electricity demand could increase by 75% by 2050, with emerging economies accounting for the majority of this growth<sup>30</sup>. It will, however, vary regionally, and the demand growth will not be spread out equally around the globe or even between regions. In the EU, demand is projected to raise by 40-93% by 2050, reaching at least 4400 TWh<sup>31</sup>.

Figure 7: Growth in final electricity demand, 2015-2050, EU27+UK (TWh)



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Source: Decarbonisation Speedways, Eurelectric 2023.

However, achieving energy security does not merely depend on meeting growing demand but also on mitigating its growth through improved energy efficiency. This will play a pivotal role in managing the balance between increased electricity consumption and the decarbonisation goals. Efficiency measures in buildings, industrial processes, and transportation systems can reduce electricity consumption significantly while maintaining economic productivity.

The IEA estimates that energy efficiency improvements alone could account for 40% of the emissions reductions needed to achieve net-zero targets by 2050<sup>32</sup>. By integrating efficiency into energy planning, system costs can be reduced, energy security enhanced, and a sustainable energy transition ensured.

<sup>30</sup> Net Zero by 2050. A Roadmap for the Global Energy Sector. IEA, 2021. <https://www.iea.org/reports/net-zero-by-2050>

<sup>31</sup> Decarbonisation Speedways, Eurelectric 2023, <https://www.eurelectric.org/publications/decarbonisation-speedways-full-report/>

<sup>32</sup> Net Zero by 2050, IEA, op. cit.

## 4.2. Flexibility is key to avoiding disruptions in a renewables-based system

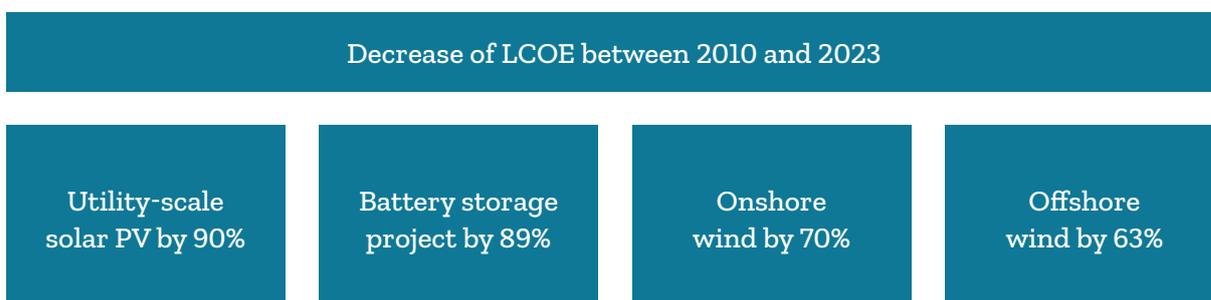
As RES become dominant in electricity generation, variability in output will become an inherent feature of the energy system. Already in 2030, the RES share of the electricity mix in the EU is expected to reach more than 60%, attaining between 75% and 80% in 2050<sup>33</sup>. Unlike conventional power plants, RES electricity generators depend on weather conditions, leading to fluctuations in electricity production that must be carefully managed to ensure grid reliability.<sup>34</sup>

In this circumstances, the flexibility of the system will be of paramount importance. It refers to the ability of the electricity system to balance supply and demand in real time when the high output of RES exceeds demand but also when there is not enough capacity to cover demand during low output. There are two main types of flexibility needs: short-duration flexibility, from seconds up to a few hours to balance the system within the day, and long-duration flexibility, up to several weeks, to compensate for long events such as winter or a shortage of wind/solar and hydro generation (like Dunkenflaute). According to ACER<sup>35</sup>, flexibility needs will double by 2030 and thus require a broad mix of clean and flexible resources to overcome this challenge.

## 4.3. Speed and direction of technology development will shape the EU's ability to secure energy in the long term

Renewable energy is increasingly seen as a solution to a price decrease, because their OPEX is close to zero, they do not consume fuel. Technologies like wind and solar have achieved remarkable cost reductions, with onshore wind and photovoltaic are now much cheaper than fossil based generation. According to the International Renewable Energy Agency (IRENA)<sup>36</sup>:

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This trend enables countries to diversify their energy mix, reduce dependence on fossil fuel imports, and stabilise long-term energy costs. However, they entail significant upfront investments in infrastructure and grids, which may temporarily increase the costs. When integrating different generation technologies into the power system, other expenses going beyond the generation source should also taken into account. These costs arise due to factors such as grid expansion, balancing needs, and adequacy requirements to maintain system reliability. Unlike LCOE, which measures the direct cost of generating electricity from a specific asset, system costs capture broader impacts on the power network, including transmission investments, reserve capacity, and flexibility requirements. RES typically impose higher system costs due to their intermittent nature, necessitating backup generation, storage solutions, or enhanced grid interconnections.

<sup>33</sup> DG Energy. Source: [https://energy.ec.europa.eu/topics/markets-and-consumers/electricity-market-design\\_en](https://energy.ec.europa.eu/topics/markets-and-consumers/electricity-market-design_en)

<sup>34</sup> System Flexibility Needs for the Energy Transition, Entso-e 2024, <https://www.entsoe.eu/system-flexibility/>

<sup>35</sup> Flexibility solutions to support a decarbonised and secure EU electricity system. Acer and EEA report, 2023; [https://www.acer.europa.eu/sites/default/files/documents/Publications/EEA-ACER\\_Flexibility\\_solutions\\_support\\_decarbonised\\_secure\\_EU\\_electricity\\_system.pdf](https://www.acer.europa.eu/sites/default/files/documents/Publications/EEA-ACER_Flexibility_solutions_support_decarbonised_secure_EU_electricity_system.pdf)

<sup>36</sup> Renewable Power Generation Costs in 2023, IRENA. <https://www.irena.org/Publications/2024/Sep/Renewable-Power-Generation-Costs-in-2023>

#### 4.4. Diverse portfolio of clean energy technologies is at our fingertips

Clean energy technologies, including smart grids, play a crucial role in enhancing energy security by reducing dependence on imported fossil fuels, diversifying energy sources, and improving system resilience.

First, they mitigate risks associated with geopolitical tensions and supply disruptions. By producing energy locally, one can strengthen energy independence and stabilise prices, shielding economies from volatile fossil fuel markets.

Second, clean energy technologies contribute to diversification by integrating multiple energy sources into the grid. A well-balanced energy mix reduces vulnerability to single-source failures and enhances overall system stability.

Third, modernised grids and smart energy infrastructure improve resilience against cyber threats, extreme weather, and equipment failures. Advanced grid technologies, including microgrids and energy storage, enable decentralised energy production, allowing communities to maintain power during disruptions.

#### 4.5. Emission constraints and climate change impacts force rapid shift to low-carbon energy while exposing infrastructure to new risks

Reducing greenhouse-gas emissions and adapting to climate change deeply influence energy security. As countries strive to meet global climate targets, energy systems must undergo rapid decarbonisation. This transition requires reducing reliance on fossil fuels, which currently dominate the energy supply, and scaling up low-carbon alternatives like renewables, nuclear, green hydrogen, or biogases.

Pathways to decarbonisation imply the overhaul of energy systems and industrial production, particularly those that are energy intensive. It requires rapid grid modernisation, the deployment of flexible solutions, and the further development of low-carbon generation. Furthermore, phasing out coal, oil, and natural gas increases the risk of short-term disruptions if alternative sources or technologies are not deployed at sufficient pace or the costs of new technologies rise.

Climate constraints further exacerbate risks to energy infrastructure. During extreme heatwaves, the demand for cooling surges, putting pressure on power grids and increasing the risk of system failure. Overheated transmission lines can sag and malfunction and transformers can explode from thermal stress. Furthermore, thermal power plants relying on water for cooling face operational constraints when intake water temperatures exceed safe limits, forcing shutdowns and reducing energy availability during critical times. Renewable energy sources are also vulnerable to climate extremes. Photovoltaic panels lose efficiency under prolonged high temperatures, while wind turbines are affected by irregular weather patterns and intense storms.

Severe weather events such as hurricanes and floods threaten coastal power plants, substations, and energy storage facilities. Flooding can damage critical electrical components and wildfires from prolonged droughts can damage transmission lines, leading to widespread blackouts and costly repairs.

#### 4.6. Fuel and resource supplies are diverging, yet they remain essential

The European economy is structurally dependent on fossil fuel imports, with EU countries spending hundreds of billions of euros each year on energy product imports, as shown above. It has long been a vulnerability in its energy security.

Shifting away from fossil fuels is expected to reshape global trade, driving a significant switch in flows of resources and leading to the emergence of more regional markets. Currently, fossil fuels account for a large part of maritime cargo, but in the future long-distance energy trade will decline. Additionally, clean energy commodities like green hydrogen or ammonia are unlikely to be traded in large quantities and its geographical spread would be different.

In the future, global trade in clean energy is anticipated to diversify and expand. New trade patterns will emerge, differing substantially from the traditional fossil fuel trade. The potential disruption would be not so significant because the producers and regions would be much more diversified and dependency relations not as interconnected.

Another shift is related to electrification and the growing role of electricity, which could foster more regional-scale relationships. The electricity systems must be interconnected by physical lines, be it onshore or offshore, so most of the trade in electricity will take place at the regional level. The integrated EU electricity market exemplifies this dynamic, where countries benefit from enhanced integration. Interconnectors enable the exchanges and allow for deeper integration.

Transporting clean energy is often more challenging than producing it domestically. For example, hydrogen and electricity have significantly higher transportation costs per unit of energy compared to oil or coal. However, there may still be opportunities to trade clean energy products that contain a substantial amount of embedded energy, such as ammonia. Moreover, clean energy can be directly imported through power lines from nearby countries or relatively short pipelines. Examples include hydrogen from North Africa, biomethane from Ukraine, and hydro electricity from Norway.

Clean technologies require, however, secure access to raw materials. Critical minerals like lithium, cobalt, and rare earths are essential for the production of batteries, solar panels, and wind turbines. These materials are often difficult to source and extract, requiring specialised mining, processing, and refining techniques. Many of these resources are also finite, with supply constraints becoming an increasing concern for economies looking to meet the demands of modern technology and environmental sustainability.

For instance, China has emerged as a dominant player in global supply chains in critical raw materials. Its strategic approach to controlling these supply chains has far-reaching implications for the global economy, geopolitics, and sustainability efforts worldwide. For instance, it controls over 70% of the world's rare earths production and processes 90% of the global supply of them<sup>37</sup>. It has established large mining operations in key regions such as Africa and South America, which allows it to secure the primary source of these materials<sup>38</sup>. With the transformation of the energy sector in the EU, securing an uninterrupted supply of critical minerals will be a priority over the next decades.

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#### 4.7. Ensuring system adequacy in infrastructure planning

Matching electricity supply, transmission, distribution, and demand is key for energy security. This requires both the seamless cooperation of hundreds of thousands of connected elements in real time, as well as necessary investment decisions, often more than a decade in advance of their operation (e.g., for grids, big industrial consumers, or nuclear plants). With increasing electrification, ensuring the system is adequate at any moment becomes even more important, as heating, transport, data, and other essential services are all dependent on a functioning electricity system.

Public incentives will play a strong role, even in the most market-driven electricity sectors (see also next section). Network development is based on publicly regulated incentives (that are typically guided by network development plans). Generation investment depends at least on public approval and licenses, but is often also guided by public subsidies (renewable support schemes, CfDs). Also, on the demand-side, public policies steer private investment choices (e.g., building-standards, EV subsidies, carbon prices).

The challenge with system planning is that the system has no “natural” borders. When looking at the efficiency and security of a country's electricity supply, it is also important to consider various elements such as electricity demand, grid development of different energy carriers, and neighbouring countries' systems. Hence, a planning process that at least represents the main interfaces between the different areas in a consistent way is needed to produce reliable results.

37 The Role of Critical Minerals in Clean Energy Transitions – Analysis - IEA, <https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions>

38 Critical Raw Materials, Economic Statecraft and Europe's Dependence on China, IFRI 2024, <https://www.ifri.org/en/external-articles/external-publications/critical-raw-materials-economic-statecraft-and-europes>

#### 4.8. Market design is key to proper energy system functioning

As the share of renewables increases, ensuring energy security will require a well-designed electricity market that effectively integrates various generation sources, demand response, and flexibility options. A properly structured market model will help balance supply and demand in real time, support efficient investment in dispatchable capacity, and incentivise the development of storage and demand-side management. Transparent price signals and mechanisms such as capacity markets or ancillary service procurement will be essential in maintaining grid stability. Multicommodity market integrating energy, capacity and other attributes of the power system needed for its proper operation (i.e. inertia) would likely be required in the future to ensure supply security. Furthermore, regulatory frameworks must ensure that energy affordability is not compromised, preventing excessive costs for consumers while sustaining economic viability for market participants. The challenge is to ensure that private action contributes to energy security rather than to reducing it. The main risk is that any public investment into increasing capacities to achieve a higher degree of energy security will be crowded out by private investors reducing their corresponding investments. For example, a state that sets up a strategic natural gas reserve but then releases some of it when prices increase, reduces the incentives for private investors to have their own gas storage for such situations. The same holds for reserve power plants, among others. Setting up market frameworks that remunerate private actors to provide the right amount of “insurance” against adverse shocks is not easy, but certain tools (e.g., capacity mechanisms) as well as rules (e.g. reserve requirements) have already been developed and tested in individual jurisdictions. Finding a European framework could substantially increase the effectiveness and efficiency of such frameworks.

#### 4.9. Infrastructure resilience to physical threats

Increasing electrification and dependence on uninterrupted access to electricity and its sources has made energy infrastructure components an attractive target for hostile states, criminal groups, and terrorists. To date, energy infrastructure has been developed while taking into account cost efficiency and system redundancy in case of technical failures.

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The Russian invasion of Ukraine has shown that energy infrastructure can become a top target, right after military ones, as the electricity supply is vital for a state’s functioning and everyday life. The targeting includes kinetic (weapons-based) attacks, as well as cyberattacks, sabotage, and acts of terrorism. Ukraine and the Baltic States already experienced this when Russian hackers induced power cuts and blocked systems of main government institutions (more on cyber in next section). In the US, a complete “toolbox” for hostile control of critical infrastructure—“Pipedream”—was discovered<sup>39</sup>. In the future, such instruments will be an increasing threat to such systems.

The critical infrastructure of EU countries, including energy, is already being targeted by attacks for which it is not sufficiently prepared<sup>40</sup>. Recent incidents in the Baltic Sea involving undersea cables and pipelines clearly shows that this kind of sabotage may threaten the development and proper functioning of a country. Energy infrastructure facilities—generation, grids, storage, control centres—must be resilient to any kind of attack, be it a physical intrusion, drone or cyber.

#### 4.10. While digitalisation increases, cyber threats appear more often and are more severe

The transformation of the energy sector along with widespread digitalisation is revolutionising how energy is produced, distributed, and consumed. Technologies such as smart grids, Internet of Things (IoT) devices, and artificial intelligence (AI) are enabling unprecedented efficiency and reliability of energy systems.

<sup>39</sup> <https://homeland.house.gov/wp-content/uploads/2024/02/2024-02-06-CIP-HRG-Testimony.pdf#page=4>

<sup>40</sup> <https://www.politico.eu/article/baltic-sea-cable-damage-germany-sabotage/>

Digital technologies are becoming increasingly vital to the energy sector. A smarter energy system can manage power generation, transmission, network operations, and market-related tasks with greater precision and faster response times than human-dependent systems.

Digitalisation aims to optimise operations and enable remote supervision and monitoring of increasingly complex systems. As energy demand is set to rise, efficient and optimised energy usage becomes critical, including demand-response measures. These services leverage interconnected smart devices, such as sensors and actuators, extensively deployed in households and businesses. Projections indicate that the number of these devices and wider usage of IoT will reach several billion euros in the near future<sup>41</sup>.

Digitalisation enables real-time monitoring and automation of energy systems, reducing waste and optimising resource utilisation. Smart meters and connected devices empower consumers to make informed decisions about energy consumption, while predictive analytics enhances the management of RES. Moreover, digital platforms facilitate decentralised energy production and distribution, fostering the growth of microgrids and peer-to-peer energy trading.

Energy control systems rely on interconnected physical and electronic devices operating in real time and linked to a control centre. These systems include supervisory control and data acquisition (SCADA) systems, widely used for monitoring and managing dispersed energy networks. SCADA systems collect, display, and store information from control equipment and automated devices, forming part of real-time process control systems that manage tasks like electricity transmission and distribution or gas pipeline operations.

These advancements, however, also open the door to significant cybersecurity risks. The attack surface has expanded due to the proliferation of data interfaces, which provide new entry points for attackers, and the extensive use of ICT. Energy systems are attractive targets due to their potential for significant disruption, such as major supply interruptions or access to sensitive information. Additionally, with the growing development of data hubs and cloud services, the growing volume of private or business customer data accessible to service providers, utilities, and third-party partners creates further motivation for cyberattacks<sup>42</sup>.

Cyberattacks on energy infrastructure can have far-reaching consequences, including power outages, financial losses, and threats to national security. For instance, ransomware attacks on energy companies can disrupt operations, while hackers tampering with grid systems can destabilise electricity supplies. Threat actors, ranging from individual hackers to state-sponsored groups, exploit these weaknesses to gain unauthorised access, steal sensitive data, or sabotage critical systems.

In 2022, German wind turbine manufacturers and service providers experienced a cyberattack and lost communication with thousands of their wind turbines. It is necessary to change the approach to the construction and maintenance of such systems. The logic of economics and technological redundancy must be complemented by considerations of resilience to physical and cyber threats<sup>43</sup>.

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41 2024 Report on the state of Cybersecurity in the Union, ENISA 2024, <https://www.enisa.europa.eu/publications/2024-report-on-the-state-of-the-cybersecurity-in-the-union>

42 Cyber Security in the Energy Sector, EECSP 2017, [https://energy.ec.europa.eu/system/files/2017-03/eecsp\\_report\\_final\\_0.pdf](https://energy.ec.europa.eu/system/files/2017-03/eecsp_report_final_0.pdf)

43 <https://www.reuters.com/world/europe/kremlin-asked-about-damaged-baltic-pipeline-says-threats-russia-unacceptable-2023-10-23/>

Figure 8: Major cyberattacks on the energy industry, 2023



Source: ECFR, [ecfr.eu](https://ecfr.eu)

#### 4.11. Human dimension: ensuring reliable access and a just transition

Access to reliable and affordable energy is a fundamental component of everyday life. The lack of reliable energy exacerbates poverty and inequality, leaving communities vulnerable to economic and social instability. For instance, without electricity, hospitals cannot provide essential medical services, schools cannot operate, and clean water supply systems do not work. Thus, the human dimension will also impact energy security policies.

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A well-managed transition prevents economic disruption in fossil fuel-dependent regions, while workforce development is crucial to avoid delays in the shift to clean energy. As fossil fuel industries decline, mining regions face economic uncertainty, risking job losses and stagnation. A just transition framework, including job retraining, economic diversification, and investment in new industries, is essential to support these communities.

Meanwhile, the clean energy sector can face a skills gap, slowing deployment and rising costs. Without workforce training in renewables and grid modernisation, even well-funded projects risk delays, threatening both energy security and climate goals.

## Chapter 5.

### Pillars of a new energy security approach

#### 5.1. New paradigm: the energy transition as a pathway to energy security

The energy transition, a shift from an era of fossil fuel dominance to one of clean energy and electrification, can allow for a reduction in energy dependencies while strengthening energy security. Reliance on fossil fuels, especially when they are imported from politically volatile or adversarial countries, entails risks. This was demonstrated by the Russian aggression against Ukraine, which exposed Europe's vulnerability due to its dependency on Russian natural gas. The sudden gas disruption forced Europe to scramble for alternative sources to maintain the stability of power generation and gas-reliant industries. Speeding up and ultimately completing the energy transition would not only achieve the environmental sustainability of the European energy system but also it would address issues related to energy import dependency. By reducing reliance on imported oil and gas, countries can shield themselves from the price volatility, supply shocks, and political blackmail that often accompany fossil fuel markets. The expansion of RES capacity during the 2021-2022 energy crisis helped mitigate its worst effects<sup>44</sup>. Furthermore, according to the IEA, the importance of renewables is increasing every year, with a new record being set in 2023 for the commissioning of new RES projects<sup>45</sup>.

Transitioning to RES necessitates investments in grid infrastructure, which has further security consequences. Modern, decentralised, and interconnected grids are more resilient to sabotage or direct military aggression, although it creates different challenges related to cyber threats. Ukraine, as a country facing sustained attacks on its energy infrastructure, serves as a critical case study for the EU in developing a comprehensive resilience strategy, offering key insights into strengthening energy systems against both physical and cyber threats. It also shows the significance of interconnections with neighbouring countries and how important it is to rebuild energy systems towards decentralisation which allows for greater flexibility in power distribution, meaning that even if one part of the grid is compromised, other areas can continue to function, reducing the risk of widespread blackouts.

The energy transition also has long-term economic benefits and contributes to economic security. As global energy demand rises, fossil fuel prices are likely to increase, subjecting nations to price volatility and inflationary pressures that can destabilise economies. In contrast, renewables generally involve higher upfront costs but have minimal operational costs, providing a stable, predictable energy price over time. This stability can insulate economies from the price shocks associated with fossil fuel markets, fostering a more predictable economic environment that benefits industries, consumers, and governments alike.

In sum, the energy transition is not only a response to climate change but also a way to enhance energy security and reduce geopolitical vulnerabilities. As the EU will continue to be dependent on imports of fossil fuels from third countries for some time to come, it is important that the new thinking on energy security maintains a sensitivity to the security of supply while focusing primarily on those measures that serve to accelerate the energy transition.

#### 5.2. Energy security principles

To effectively address the EU's energy security challenges, a new approach must be built on two key principles: **multidimensionality and collectiveness**. Multidimensionality requires integrating various EU policies, from energy and trade to security and technological innovation, into a unified strategy. This means moving beyond the traditional focus on fossil-fuel supply security to a broader perspective that includes infrastructure resilience, digitalisation, and environmental adaptation. At the same time, collectiveness underscores the necessity of coordinated action between EU institutions, member states, and international allies to enhance resilience against external pressures, particularly from suppliers that exploit energy dependencies for political leverage.

<sup>44</sup> <https://www.iea.org/news/renewable-power-on-course-to-shatter-more-records-as-countries-around-the-world-speed-up-deployment>  
<sup>45</sup> <https://www.iea.org/reports/renewables-2023/executive-summary>

### 5.3. Multi-dimensionality of energy security: integrating trade, defense, clean industry, and climate resilience

So far, the EU's approach to energy security has been largely reactive, centred on energy policy, i.e., securing fossil fuel supplies through emergency mechanisms, such as solidarity provisions triggered in times of crisis. Given that fossil fuel imports remain a reality for many EU member states, existing frameworks should be updated rather than discarded. However, a stronger demand-side strategy is also necessary—one that aligns with national energy policies (such as National Energy and Climate Plans) to systematically reduce reliance on external suppliers while ensuring cost-effectiveness and efficiency. Accelerating the transition away from fossil fuels, particularly Russian energy imports, is critical not only for reducing geopolitical vulnerabilities but also for meeting climate objectives.

#### Trade, defence, clean industry and technology: new pillars of a multidimensional approach

Beyond energy policy, trade instruments should become a more active tool in securing energy security. The EU must be ready to leverage **customs and trade policies** to favour reliable energy partners while restricting access to those who use energy as a geopolitical weapon. This could include preferential tariffs for trusted suppliers and more restrictive measures against actors like Russia, which have previously weaponised energy dependencies.

Energy security is also deeply **intertwined with defence and infrastructure protection**. Cooperation between EU institutions and defence organisations like NATO is crucial to safeguarding vital energy assets, from gas pipelines and LNG terminals to electricity grids and undersea cables. Recent initiatives, such as NATO's Baltic Sentry mission<sup>46</sup>, which strengthens regional security against sabotage, demonstrate the growing recognition that energy infrastructure must be protected from both physical and cyber threats. The security of offshore wind farms and undersea interconnectors will be particularly important as the EU increases its reliance on renewable energy sources.

Given the rising geopolitical tensions, Russia's aggressive policies and changing fuels regulations, the EU's energy security strategy must address also military needs. Today's armed forces depend on a **stable fuel supply for military mobility and operational effectiveness**. Fossil fuel supplies are vulnerable to disruption from global instability and climate policy constraints. Biofuels and synthetic fuels could be a part of the solution as military could gain independence from traditional fossil fuel supply chains and fit into the EU's decarbonisation efforts. Therefore, the EU should establish mechanisms to support low carbon fuels production for military use to prevent regulatory changes from undermining Europe's defence capabilities.

Security of fuel supply requires not only production, but also efficient logistics. Investment in fuel pipelines is essential for both military and civilian use. It is necessary to interconnect the fuel pipeline systems of Western, Central and Southern Europe for reliable fuel supply during emergencies. The EU should include support for the infrastructure that can supply the armed forces and be used during peacetime (for civilian purposes)<sup>47</sup>.

**Technological progress** is another key pillar of energy security. Investment in energy innovation, smart grids, and AI-driven energy management can help optimize demand, reduce dependency on imported critical raw materials and improve overall efficiency. Expanding civil nuclear energy projects, scaling up hydrogen initiatives, and deploying smart meters across the EU will further strengthen resilience. Digitalization and machine learning (ML) will enhance grid flexibility, allowing electricity production to be forecasted and matched more precisely to demand.

Given the increasing interconnectivity and digitalisation of energy systems, **coordinated strategies for cybersecurity** will be crucial for safeguarding critical energy infrastructure in the digital era. Ensuring business continuity in teletransmission, IT operations, and application management, as well as securing servers, is a fundamental requirement for the future energy system. Smart grids and automated control systems makes the sector highly dependent on stable and resilient information and communication technology (ICT). Any disruption in teletransmission or IT operations—whether due to cyberattacks, software failures, or hardware malfunctions—can lead to severe consequences, including power outages, operational delays, and financial losses. Therefore, robust cybersecurity measures, real-time monitoring,

<sup>46</sup> [https://www.nato.int/cps/en/natohq/news\\_232122.htm](https://www.nato.int/cps/en/natohq/news_232122.htm)

<sup>47</sup> On dual use infrastructure compare: Ninisto report. Safer together: A path towards a fully prepared Union, [https://commission.europa.eu/topics/defence/safer-together-path-towards-fully-prepared-union\\_en](https://commission.europa.eu/topics/defence/safer-together-path-towards-fully-prepared-union_en)

and redundant systems must be integrated to maintain operational integrity. Additionally, adherence to international cybersecurity standards is essential to mitigating risks.

The multidimensional approach should also encompass **resilience**, which addresses the ability of energy systems to withstand various and unexpected threats. It is linked to diversity of infrastructure and technology options, but it also includes well-designed and functioning institutions capable of adapting and responding to incidents. It can also entail an appropriate framework for cooperation in case of a crisis.

**A cohesive industrial policy** is essential to align the EU's energy security and green transition goals while maintaining global competitiveness. To reduce dependence on external suppliers and develop a robust RES ecosystem, the EU must integrate energy and industrial policies, ensuring equitable progress across the member states. Currently, fragmented industrial policies create disparities, with wealthier nations advancing faster. The EU should focus on sectors where it has a competitive edge. While China dominates PV manufacturing, EU companies are strong in wind-turbine manufacturing and its capacities are growing in cobalt-free lithium-ion batteries. Investing in geothermal heat pumps, low-carbon materials, and advanced manufacturing will further bolster industrial strength and energy security.

A truly multidimensional energy security strategy must also account for **climate-related risks and therefore incorporate the EU's environmental policy**<sup>48</sup>. Extreme weather events such as wildfires, floods, and heatwaves increasingly disrupt energy production and distribution. Early warning systems and cross-border emergency response mechanisms should be essential parts of the EU's energy security framework, ensuring resilience against both man-made and natural disruptions.

#### 5.4. Collectiveness of energy security: overcoming national fragmentations to strengthen joint resilience

26 Energy security should become a **common and truly collective category in the EU**, complementing individual approaches and definitions of energy security.

The EU's energy security approach should be incorporated into national energy policy strategy documents. Adopting a common approach at the EU level would entail defining how individual countries or groups of countries can contribute to strengthening the EU's energy security, thus increasing the effectiveness of those energy security measures that are generally taken individually by particular member states. Some have noted that in recent years, progress in integrating energy markets has been weaker because there has been a lack of willingness to act in the spirit of shared responsibility for energy security. The differences that exist between member states in their approaches to energy security make it difficult to build a common strategy<sup>49</sup>.

A well-functioning internal market, in normal circumstances, should be able to aggregate sufficient EU fossil fuel demand, without the need for complex political and administrative mechanisms. It needs, however, a set of rules and principles among the member states related to a prohibition to seek special deals with foreign suppliers. Another option—a more centralised one—is to expand the mechanisms to **aggregate fossil fuel demand** in the medium and long terms at the EU level. While the intensification of energy diplomacy among EU member states in the last two years (since the beginning of Russia's invasion of Ukraine) is a positive development, the overly individualistic approach of countries is a challenge. This creates risks of stranded assets and costly contractual obligations for fossil fuel supply beyond 2050<sup>50</sup>. According to data collected by the Energy Deals Tracker<sup>51</sup>, ECFR's special tool for mapping new energy agreements concluded by the EU and member states since Russia's full-scale invasion of Ukraine, as much as 45% of the agreements concerned cooperation in the gas sector to secure supplies from alternative sources to Russia.

48 <https://www.europarl.europa.eu/factsheets/en/sheet/71/environment-policy-general-principles-and-basic-framework>, <https://static1.squarespace.com/static/64f5f132690bb40dc03cfaf4/t/657af2da2e050a25aa472da1/1702556434889/EIES+EMPOWERING+EUROPE.pdf>

49 EIES, Empowering Europe: Developing a Roadmap to Strategic Autonomy and a Competitive Energy Transition, 2023

50 <https://ecfr.eu/article/from-crisis-to-climate-europes-energy-diplomacy-after-two-years-of-war-in-ukraine/>

51 <https://ecfr.eu/special/energy-deals-tracker/>

Therefore, part of the ongoing discussions on the new EU security architecture should be the aggregation of the energy needs of the member states, the realistic options in this regard, and the possible scale of their implementation. While it is true that under EU law energy policy is a shared competence between the EU and the member states<sup>52</sup>, it would at least be necessary to harmonise the approach in this regard, coordinated by the **EU Energy Agency** or another institution set up for this purpose within the EU. An example justifying the proposal for a common approach to the EU's energy commodity needs is the gas sector. In 2023, the utilisation level of LNG regasification terminals in the EU was less than 57%. EU countries currently have as many as 38 regasification terminals, although they are unevenly located across the Union: 7 in Spain, 6 in Italy, and 5 in France. However, according to the 2024 World LNG Report<sup>53</sup>, the total regasification capacity in the EU (as of 2023) was almost 171 million tonnes. Their 100% utilisation would provide almost 77% of the EU's import needs in 2023. Carefully planned internal gas grids and interconnectors within the EU are essential to maximising the utilisation of existing LNG terminals, reducing the need for costly new infrastructure while enhancing energy security. At the same time, any new LNG terminals should be strategically located in regions where gas cannot be easily transported from other parts of Europe, ensuring they address genuine supply constraints. A well-designed approach would optimise investment allocation, avoiding stranded assets and preventing unnecessary expansion of fossil fuel infrastructure that could undermine the EU's climate goals.

One of the tools to be considered in the EU's collective approach to energy security are various forms of **joint purchasing mechanisms**. Such a platform for gas purchasing has been a topic of discussion aimed at potentially strengthening European negotiating power with external suppliers. If successful, this platform could lead to lower prices, increased EU control over the import mix, and greater leverage during crises. So far, the only real example of such an initiative is in the import of nuclear fuel, which has yielded mixed results<sup>54</sup>.

The existing European platform for gas, established during the energy crisis, operates on a voluntary basis and functions as the aggregation rather than purchasing. It has not been very effective. Voluntary schemes fail as exporters undermine them by offering better deals to individual players. There are no effective proposals that combine the skilled and highly incentivised nature of commercial actors in developing and utilising complex supply sources with the desire to pool supply negotiations.

Implementing a mandatory scheme for all European gas imports would be politically challenging on both the domestic and international fronts. Internationally, major exporters such as the US may strongly oppose such measures if they would really deteriorate their terms-of-trade and retaliate. Domestically, this approach could lead to distributional effects that might benefit smaller countries, which tend to have less political influence. A key question for further analysis is whether the economic inefficiencies from "import monopolisation" would be outweighed by the advantages of increased "leverage".

However, a **joint purchasing mechanism for critical raw materials (CRMs)** could present a more viable option, given the strategic importance of securing stable and diversified supply chains for clean technologies. Unlike gas, CRMs are often sourced from a small number of suppliers, making coordinated EU efforts more impactful in reducing the dependency on dominant players. Nevertheless, such mechanisms must be carefully designed to prevent market distortions, ensure fair competition, and align with broader industrial and trade policies. A well-structured CRM procurement strategy could strengthen the EU's resilience, but its implementation requires thorough examination to balance efficiency with economic and geopolitical considerations.

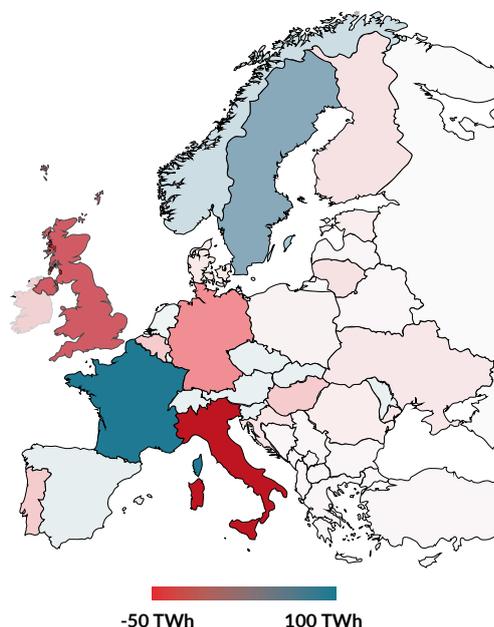
An important part of collectiveness should be **enhanced energy interconnectivity**. Integrated infrastructure and cross-border pipelines and grids strengthen the EU's energy network, enabling the seamless flow of resources across countries. This fosters solidarity and mitigates risks, ensuring that no member state faces an energy crisis alone. Additionally, interconnectivity supports the EU's transition to renewable energy by enabling balanced integration of intermittent sources like wind and solar, further reinforcing the energy independence and sustainability of the entire region.

52 <https://eur-lex.europa.eu/EN/legal-content/glossary/eu-energy-policy.html>

53 <https://www.igu.org/resources/2024-world-lng-report/>

54 <https://classic.austlii.edu.au/au/journals/AURELawJl/2006/33.pdf>

Figure 9: Cross-border exchanges of electricity in Europe



Source: Forum Energii based on ENTSO-e

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A collective approach within the European Union is essential for managing electricity balancing and gas storage, though these require distinct frameworks. For electricity, balancing platforms established under the Electricity Balancing Guideline (EBGL) play a key role in ensuring grid stability and efficient real-time energy allocation. Meanwhile, for gas, coordinated storage policies are critical to maintaining strategic reserves, mitigating supply disruptions, and ensuring resilience during demand surges. While both mechanisms contribute to overall energy security, their governance, market structures, and operational needs differ, requiring tailored yet complementary coordination strategies.

A collective approach to energy security in the EU should also **encourage specialisation** among the member states, enhancing efficiency and avoiding misguided investments. Specialisation could also extend to hydrogen production and clean technology infrastructure, optimising resources and expertise across countries. The EU goal of producing and importing 10 million tonnes of green hydrogen annually by 2030<sup>55</sup> faces significant hurdles, requiring coordinated efforts to develop cross-border pipelines, shared electrolyser facilities, and integrated RES. For example, studies suggest that importing green hydrogen from Spain or Morocco is more cost-effective than domestic production in Germany, reinforcing the benefits of a unified strategy. Specialisation within the EU in clean technology development and expanded manufacturing bases would allow the bloc to compete more effectively with global players like the US and China. Improved cooperation can be achieved through the joint negotiation of contracts with CRM suppliers and the establishment of committees or working groups to align national interests and minimise conflicts. Such harmonisation would promote a unified approach to energy challenges, amplifying the EU's collective bargaining power.

While the idea holds promise for boosting efficiency, reducing financial burdens, and fostering synergies among nations, implementation faces considerable challenges. It would require overcoming political, economic, and logistical hurdles, and ensuring that all member states are aligned in their interests and actions. Nonetheless, if realised, this approach could offer a stronger collective response to the pressing issues of decarbonisation and reducing dependency on external energy sources. Thus, it would be advisable to have an in-depth discussion on this issue in the EU in the next few years as part of the strategic planning for strengthening energy security.

**Integrated planning across sectors and at EU level** offers significant benefits over traditional sectoral and self-sufficiency-oriented national planning. Full integration allows significant savings: cross-sectoral coordination reduces infrastructure costs, while international lowers technology expenses.

Currently, hydrogen infrastructure is planned in isolation and is likely over scaled. Offshore projects, like those in the Baltic Sea, would require significant investment in transmission systems to the south. There is a need to redesign the energy infrastructure planning process so that integrated, cross-sectoral and cross-national planning becomes standard practice. It is also necessary to take into account the flexibility of the energy system in the planning process, prioritise electrification for decarbonisation and reserve hydrogen for non-electrifiable applications only. In achieving such a consistent planning process, an EU energy agency can be useful.

5.5. External dimension of the EU’s energy security

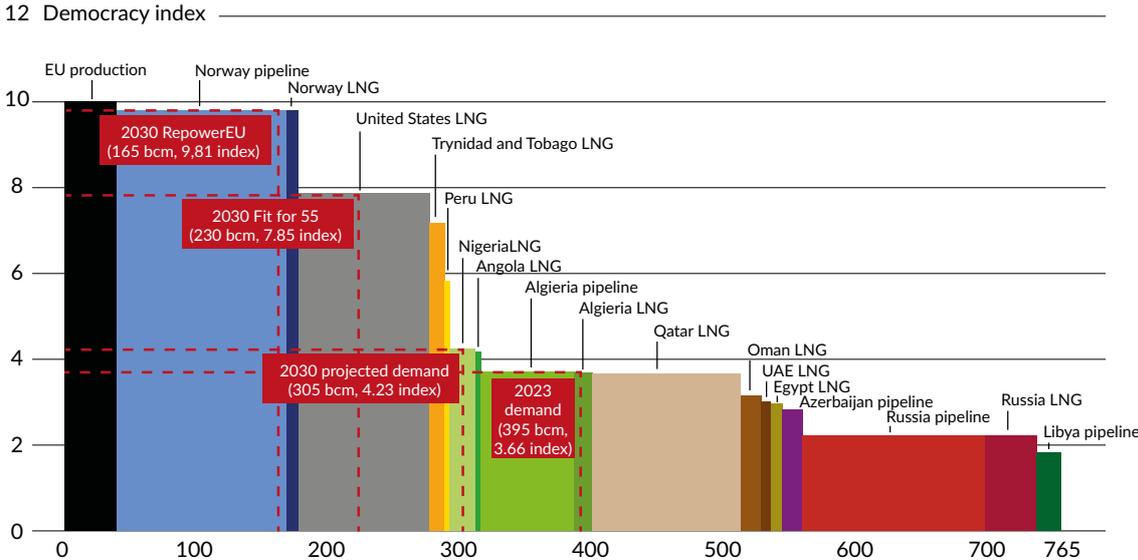
**Energy Diplomacy: coordinating negotiations to secure strategic and values-aligned suppliers**

An important element of the collective approach should be the wider use of **EU energy diplomacy**, which should be an important instrument for strengthening energy security. Coordinating the efforts of individual member states and working together on energy diplomacy may be necessary, given the current geopolitical challenges. The EU should be ready to maintain a strategic relationship with the US in energy (an important supplier of gas, nuclear technology and nuclear fuel), with the assertiveness to defend those sectors of European industry that serve the energy transition. In practice, this means the EU must be assertive in protecting its own clean energy industries from unfair competition, market distortions, or excessive dependence on external suppliers. This approach safeguards Europe’s energy transition efforts, ensuring that domestic industries remain competitive and resilient.

As the EU will remain dependent on imports of fossil fuels, maintaining a diversified supplier portfolio is critical. As the gas import mix evolves, new risks arise and must be considered when selecting suppliers. Reducing overall fossil fuel demand allows EU importers to be more selective about potential sources and better optimise the import basket based on price and multiple non-price criteria (for instance, friend-shoring, derisking, climate objectives, transport modes, and interdependency)<sup>56</sup>. For instance, if we take the democracy index as a proxy to identify suppliers that share the EU’s fundamental values based on the political system, with lower demand levels, the EU can avoid reliance on the most authoritarian regimes of Libya and Russia and reduce dependence on Azerbaijan, Egypt, the UAE, Qatar, Oman, Algeria (Figure 10).

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Figure 10: Ranking of gas exporters by the democracy index.



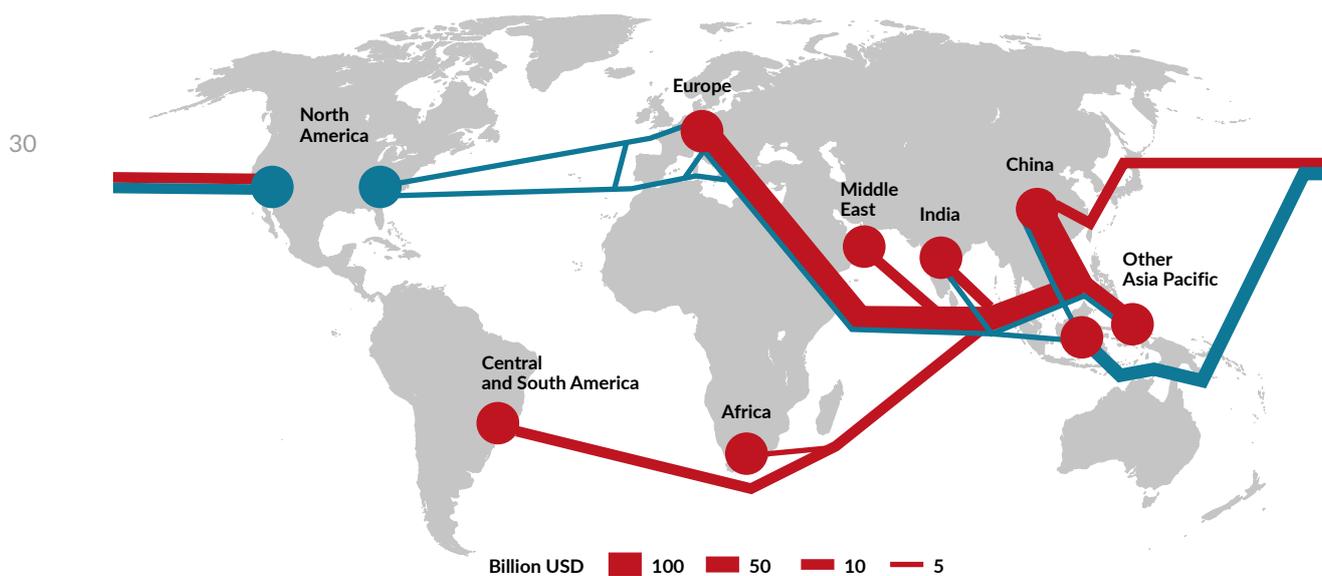
Source: Bruegel.

Accelerating the energy transition will in turn require further agreements on the import of CRMs, rare earths, as well as green hydrogen, or biomethane. In order to strengthen their negotiating position, EU member states should combine their efforts to negotiate new supply agreements for commodities relevant to the transition processes. Where possible, the EU should become a party to such agreements, which should, as far as possible, consider the aggregated needs of the member states.

Existing cooperation channels should be leveraged for CRM imports alongside limited domestic extraction efforts. The EU has actively pursued agreements with CRM-rich nations like Argentina, Brazil, and Canada. Additionally, the EU is deepening engagement in global initiatives such as the Minerals Security Partnership and the Sustainable Critical Materials Alliance to promote sustainable CRM supply chains. Domestically, the European Raw Materials Alliance aims to enhance internal CRM capabilities.

Energy diplomacy activity should be expanded to other sectors such as fuels, and technologies critical to the functioning of the European economy—oil, liquid fuels (including e-fuels), gases (including biogases), hydrogen and its carriers (ammonia), electricity or electromobility. The Global Gateway, launched in 2021, is the EU's strategy to develop global connections in digital, energy, and transport. The initiative focuses on promoting smart, clean, and secure investments in quality infrastructure, adhering to high environmental and social standards and creating links that benefit people and the planet, while aligning with the EU's values and standards.

Figure 11: Main inter-regional trade flows for key clean energy technologies in the State Policies Scenario.

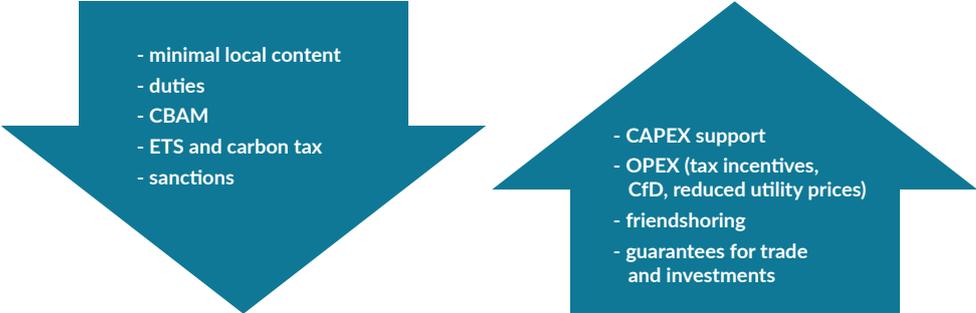


Source: IEA base on Oxford Economics Limited (2024); CEPII (2024); and Verschuur (2022).

The role of EU production support (inshore) policies should not be overlooked. The EU is under tremendous pressure from protectionist policies in the area of clean technologies mainly from China and the US. From this angle, policies aimed at reducing CAPEX and OPEX (contracts for difference, tax incentives, reduced utility prices) in the area of key technologies should be understood as a form of investment in energy security and justified state aid. Also, tightened local-content requirements are legitimate.

At the same time, it should be noted that support policies have a differential impact on energy costs for end users. Therefore, it is necessary to ensure that measures that result in higher costs (local-content, tariffs, sanctions) are properly balanced with measures that reduce them (tax incentives, CfDs, CAPEX support).

Figure 12: The impact of selected energy security policies on the costs to the EU economy.



Source: Forum Energii

**Securing supply chains and strategic stockpiling: developing resilient and diversified import channels**

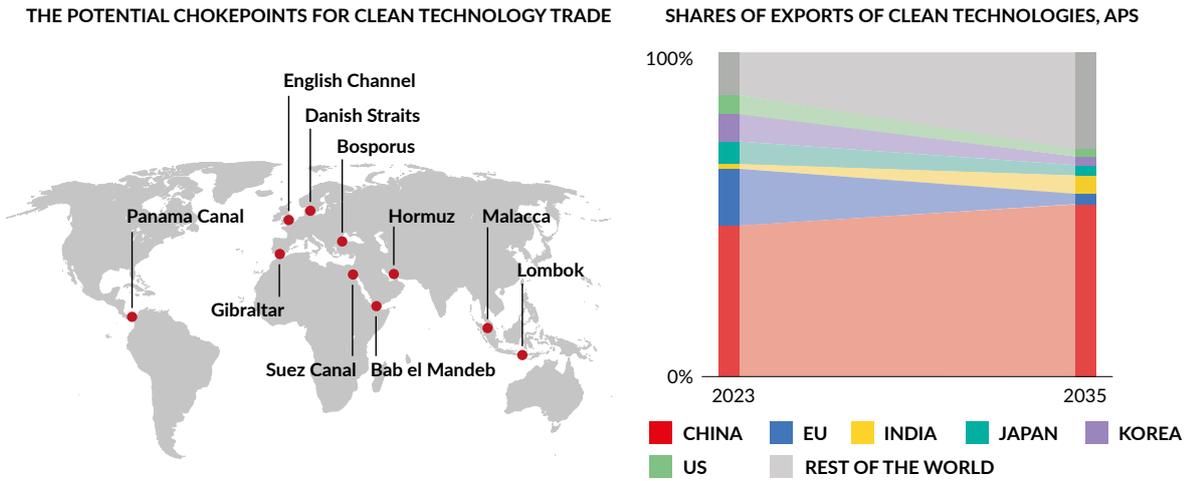
Due to the high dependence on imports, the EU must ensure **the resilience of its supply chains**. Their disruption in the area of energy and energy technologies can hinder the energy transition and impose serious costs on EU economies. Resilient supply chains (which respond flexibly to market shocks and non-market risks) enable an uninterrupted supply of raw materials, semi-products, and goods at affordable prices and in quantities that meet demand.

The main risks to the resilience of EU supply chains include<sup>57</sup>:

- High concentration of supply, a situation in which high dependence on a single supplier increases the vulnerability of deliveries to local crises or political risks;
- Transportation bottlenecks, the high dependence on single routes (e.g., the Suez Canal) makes deliveries vulnerable to local crises or political risks;
- Lack of coordination of infrastructure build up, the uncoordinated commissioning of generation capacity and supply chain elements can disrupt the natural economic cycle and inhibit the implementation of climate policies.

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Figure 13: Clean technology trade and barriers



Source: IEA, Energy Technology Perspectives 2024.

57 Energy Technology Perspective IEA, <https://iea.blob.core.windows.net/assets/48d2ba37-f198-4e85-a978-faaea70ea4aa/EnergyTechnologyPerspectives2024.pdf>.

Accurate identification of risks associated with supply chains and import dependency is difficult to carry out due to the lack of precise data. Customs information based on current classifications of goods and services does not allow accurate identification of individual components (e.g., PV plant components and electrolyzers) and entire commodity units (biomethane). This makes detailed analysis, as well as the political process, very difficult.

In view of the high importance to the EU of maritime supplies and the unrelenting risk of piracy and state-terrorism (especially in the Horn of Africa), further cooperation and coordination of maritime security efforts in this area between the EU and NATO is essential<sup>58</sup>.

Sufficient European stockpiling of products that cannot be quickly substituted, such as nuclear fuels or certain materials, should be monitored, and if the market does not provide them, public interventions such as storage obligations or strategic reserves need to be considered. This type of action is proposed by the IEA under the Voluntary Critical Minerals Security Program<sup>59</sup>. China, too, is building up stockpiles (e.g., of cobalt) to increase its resilience to price fluctuations of critical materials on global markets.

### Cooperation with neighbourhood

An important contribution to the EU energy security can be achieved in **cooperating with its close neighbourhood, particularly with Ukraine**, which is steadily advancing in its European integration. Amid shifting geopolitical tides, Ukraine could emerge as a factor reinforcing the EU's energy security, with its vast resources and strategic infrastructure. It possesses massive underground gas-storage facilities (320 TWh) in western part of the country that are currently underutilised and can constitute an important element of European gas storage system for winter seasons. Ukraine still holds substantial fossil gas reserves and has seen a slow but steady increase in the production of fossil gas and biomethane, even during the war.

32 Ukraine is also carving out a new role in the green transition. Huge potential lays in biomethane production and its potential export to European partners through existing pipelines<sup>60</sup>. The same stands with Ukraine's potential as a future green hydrogen hub. Meanwhile, well-developed electricity interconnections between Ukraine and the EU, synchronised with Continental European network since 2022, can become a key element in balancing electricity flows, supporting neighbours in times of crisis while preparing to harness its full renewable potential, especially in the south and on the Black sea coast.

To build a future-proof energy security strategy, the EU must adopt a multidimensional approach that integrates energy, trade, defence, and climate policies into a cohesive framework. At the same time, collectiveness—cooperation between EU institutions, the member states, and international allies—must remain at the heart of the EU's strategy. Only by combining these principles can the EU reduce its geopolitical vulnerabilities, accelerate the clean energy transition, and ensure long-term security and resilience.

58 EEAS, EU-NATO cooperation, [https://www.eeas.europa.eu/eeas/eu-nato-cooperation-factsheets\\_en](https://www.eeas.europa.eu/eeas/eu-nato-cooperation-factsheets_en)

59 <https://www.iea.org/news/iea-summit-on-critical-minerals-and-clean-energy-key-takeaways>

60 The potential of Ukraine-EU biomethane cooperation, GDU, <https://greenddealukraina.org/events/the-potential-of-ukraine-eu-biomethane-cooperation>

## Chapter 6.

### A new European Sustainable Energy Security Strategy

The European Union faces multilayered challenges in ensuring energy security stemming from its reliance on external energy supplies, the transition to a sustainable energy system, and geopolitical instability. These challenges are compounded by the urgency of achieving climate goals while maintaining energy affordability and resilience.

As most of the definitions and concepts of energy security to date mainly refer to fuel supplies and thus represent a narrow view of energy security, there is a need to revise the definition to encompass the broader context.

#### 6.1. Proposal for a revised definition

*We propose to define **sustainable energy security** as the ability of a flexible and resilient energy system to reliably provide sustainable and accessible energy services, critical minerals and technologies, while adapting to evolving challenges related to climate change and environmental constraints as well as cyber threats, without unduly burdening consumers.*

This definition involves securing a diversified and resilient supply of energy resources and critical materials, managing energy demand and supply efficiently, and ensuring economic and social stability and equity. It encompasses a broader range of aspects that interact with the energy systems of the future.

#### 6.2. Key goals: prioritising domestic clean electricity production to lower cost and environmental footprint

Ensuring the security of energy supply amidst the energy transition is crucial in combination with climate and environmental protection. Sustainability and electrification should be at the core of the strategy, reflecting a more comprehensive understanding of the factors that can impact energy system security. The strategy should evolve toward prioritising the development of zero and low-carbon electricity generation, flexibility of sources, and demand-side response, while ensuring reliable grid operation, uninterrupted electrification, and sector integration.

The strategy must encompass not only fuel supply security but also system operational security and adequacy. With a high share of renewables, a well-designed market model, adequate dispatchable capacity, and sources of flexibility will be indispensable. The strategy should be developed to avoid overburdening consumers and ensure energy prices remain moderate while keeping operating costs in check.

#### 6.3. Toolbox for achieving sustainable energy security

To achieve sustainable energy security in the European Union, the EU should adopt or enhance the suite of targeted tools and mechanisms.

##### European sustainable energy security strategy

The tremendous changes that affect energy security we describe in this paper necessitate strategic guidance enshrined in political documents. Therefore, the EU needs a **new European sustainable energy security strategy**. It should not only include a new definition of sustainable energy security but also be a comprehensive, long-term action plan, considering the aggregated needs of the member states and the energy and climate policy objectives adopted in EU law. This strategy must address both the diversification of energy sources and the development of supply chains for CRM resilient to geopolitical vulnerabilities.

The EU's energy security is inherently interdependent, making coordination of national measures critical. While each member state is responsible for ensuring its own energy security, the collective strength of the EU far exceeds the sum of individual efforts. **The strategy, based on the principle of multidimensional security and a collective approach,** should be a reference point for action by the EU and the member states. A well-coordinated approach can mitigate risks, optimise resources, and prevent vulnerabilities that arise from isolated decisions.

The strategy should be **concretised both by legislative action taken by the EU institutions and by strategic planning at the level of the member states.** Changes to EU law should aim to enable the EU institutions to make the most effective use of the instruments provided for under various policies (trade, energy, environment, transport, etc.) to strengthen energy security.

Action at the national level, in turn, should be based on the implementation of a common approach to energy security in national strategic documents, with the National Energy and Climate Plans at the forefront. Ideally, the EU-agreed definition of energy security should be incorporated into the energy strategy documents of the individual member states.

### Repowered security of supply

The strategy should address both the diversification of energy sources and the development of resilient supply chains for fossil fuels and critical raw materials.

**Strengthening the EU's security of supply requires a diversified and strategically managed approach to energy imports.** Establishing import thresholds to prevent over-reliance on any single country while prioritising democratic suppliers such as Norway, the US, and Canada will enhance supply stability and reduce geopolitical risks. Additionally, implementing "friendshoring" practices by deepening trade relationships with countries that align with EU values will help secure reliable energy and CRM supply chains, ensuring long-term resilience against market disruptions and political uncertainties.

Member States should also look beyond national borders and monitor the needs and concerns of their neighbours when making decisions that impact energy supply, storage, or infrastructure on a regional scale. **Joint aggregation platforms** can constitute an important element of the EU strategy to ensure sufficient supplies, but they need to be carefully designed and implemented. EU trade policy instruments should play a greater role in pursuing the goal of diversifying sources of fuels and CRM. **Establishing a dedicated EU Energy Agency** to facilitate joint, pan-European planning and centralised data collection could enhance policy coherence.

A renewed emphasis on the **principle of solidarity** among EU member states is crucial to fostering collective responses to energy crises and advancing shared objectives in energy security and sustainability. To operationalise solidarity, the EU should expand the strategic reserves mechanism, improve regional risk preparedness plans, and develop a legally binding Solidarity Mechanism Agreement to ensure rapid assistance in case of supply disruptions.

To accelerate its energy transition and reduce dependency, the EU must continue the policy aimed at moving away from fossil fuels in its energy mix. Such a strategy would enhance energy independence, support climate goals, and cut the import bill, currently burdened by volatile fossil fuel prices. The **phase-out of Russian fossil fuels** should be a priority in this respect, as envisaged in the RePowerEU in combining political with climate goals. By replacing Russian energy imports with renewable energy and increased energy efficiency, the EU not only reduces geopolitical risks but also drives sustainable growth. A full embargo on Russian fossil fuels would be the desired solution but seems politically difficult. If a complete ban is not feasible, a strategy for gradually reducing of Russian fossil fuels must be implemented. To prevent an uncontrolled return to Russian gas imports, either directly or due to concerns that the perceived risks deter investments in alternative energy sources, the EU needs a transparent, unified policy. Establishing EU oversight over companies importing gas from Russia is also crucial. The EU should make the widest possible use of trade policy tools (tariffs, price-cap mechanisms) to limit the attractiveness of Russian energy resources from the point of view of EU importers. This could involve punitive tariffs and/or volume quotas on these imports. Such measures would help prevent Russia from creating divisions within the EU. At the same time, the EU should ensure sufficient infrastructure and support to the most dependent countries to incentivise the shift away from Russian supplies.

### Strengthening resilience through a more interconnected energy market

Strong shocks to the energy balance in individual regions can create major distortions in individual countries. Europe has been gradually but steadily **increasing the capacity of cross-border pipelines and electricity interconnectors**, bridging some critical gaps in the internal market. But with the changing fuel mixes, rising shares of locally correlated renewables, and changing flow patterns, it will be important to ensure that enough cross-border capacity remains available to manage local shocks effectively. **Ensuring high interconnectivity between the member states is essential for enhancing the security of energy supply** and enabling the effective integration of energy markets across the continent. The strategy should promote enhanced cross-border energy infrastructure, to strengthen collective resilience. There is also a necessity to introduce **integrated planning for net-zero infrastructure**, which will bring significant benefits compared to sectoral and self-sufficiency-oriented national planning.

The strategy should also take into account **system integration**. A holistic view of the different energy carriers and their close interoperability to ensure the security of the system would be an important element of the future energy system, which should rely on a diverse set of solutions, including interconnectors, storage systems, and Power-to-X. Battery EVs can help balance short-term fluctuations by storing excess electricity and feeding it back into the grid when needed. Similarly, heat storage systems can absorb surplus energy during periods of low demand and release it when demand rises. By integrating these technologies with other sectors, such as transport and industry, the energy system can become more flexible and efficient.

**Demand response** will play a pivotal role in enhancing energy security in the EU by enabling more flexible and efficient use of electricity. Given the interconnected nature of the EU energy market, **transborder demand response measures are essential**. Coordinated strategies would allow countries to share resources and optimise grid stability, especially during cross-border emergencies or fluctuating renewable energy supply. This requires robust coordination among the member states, harmonised regulatory frameworks, and integrated digital systems to facilitate real-time information exchange and seamless operations.

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### Energy infrastructure protection

Critical infrastructure protection has recently emerged as a crucial aspect of energy security due to the Russian aggression against Ukraine and the incidents in the Baltic Sea. Therefore, it would be necessary **to improve the protection of infrastructure from emerging threats, unconventional attacks, and other risks, including cyber incidents**. The EU and member states should join efforts to protect pipelines, LNG terminals, as well as offshore wind farms and undersea interconnectors. Maritime security should be strengthened, with close cooperation with NATO and allied nations to monitor and protect energy sea infrastructure and supply routes. The needs of military in fuels supply and its transport across the continent should also form a part of the strategy.

A robust regulatory framework that integrates cybersecurity measures into energy operations is also vital to safeguard critical infrastructure from emerging threats.

### Investments in technologies and the development of clean industrial policies

**Investing in clean technologies and industries is essential for strengthening the EU's energy security by reducing reliance on external suppliers** and enhancing the resilience of the energy system. Supporting the development of smart grids, AI-driven energy management, hydrogen technology, and civil nuclear projects can optimise energy demand and efficiency, ensuring a more stable and flexible power supply. **Aligning energy and industrial policies** will help build a robust renewable energy supply chain, reducing vulnerabilities associated with external dependencies. Additionally, expanding support for domestic clean energy industries through targeted CAPEX and OPEX reduction policies, such as tax incentives and contracts for difference, will accelerate the deployment of renewables, making the EU's energy sector more self-sufficient and resilient in the face of geopolitical and economic challenges.

Expanding the role of the European Critical Raw Materials Board and establishing an EU-wide clean energy innovation fund could accelerate the development and deployment of advanced energy technologies while ensuring European energy autonomy for production of technologies and equipment.

### Improved energy diplomacy

A well-structured energy diplomacy strategy is essential for strengthening the sustainable energy security of the EU by **ensuring stable and diversified energy partnerships**. Given the EU's status as one of the world's largest markets for raw materials and energy semi-products, it should leverage this position to select trade partners strategically. Priority should be given to EU candidate and partner countries, such as Ukraine, Moldova, and the Western Balkans, by offering preferential customs conditions and investment support, including mechanisms like bank guarantees to foster long-term cooperation in clean energy development. Additionally, countries that share EU values based on democratic principles, such as the US, Canada, Japan, and South Korea, should benefit from reciprocal preferential tariffs to encourage mutual investment in sustainable energy technologies. Conversely, strategic rivals and countries engaging in unfair trade practices, including Russia, China, North Korea, Venezuela, and Iran, should be subject to enhanced scrutiny, additional tariffs, and targeted sanctions, particularly in sectors where unfair competition threatens EU energy security, as seen in the Chinese automotive sector. By aligning energy diplomacy with climate goals, economic interests, and democratic principles, the EU can build a resilient and ethical energy security framework that reduces geopolitical vulnerabilities while advancing the clean energy transition.

## Conclusions

As we have shown in this paper, the European Union must rethink its approach to energy security, moving beyond traditional fuel supply concerns to a more integrated and comprehensive framework. By combining a multidimensional and collective approach, the EU can build a resilient, future-proof energy security framework that reduces geopolitical vulnerabilities while consolidate the clean energy transition.

36 A key aspect of this new European sustainable energy security strategy will be a revised definition of energy security to one emphasising reliability, accessibility, and the ability to adapt to geopolitical, environmental, and cyber threats. Ensuring a secure supply of both energy and critical raw materials is essential for maintaining stability while transitioning to a low-carbon economy.

A well-structured sustainable energy security strategy will safeguard supply chains, strengthen EU energy diplomacy, and foster solidarity among the member states, ensuring that energy security is aligned with climate goals and economic stability. This requires strengthened cooperation between the member states, diversified supply chains, and a market structure that balances affordability with sustainability. Reducing dependence on single suppliers and fostering alliances with democratic partners will enhance long-term stability.

Europe's sustainable energy security strategy must be comprehensive and forward-looking, ensuring stability while driving the clean energy transition. By fostering cooperation, diversifying supply sources, and investing in innovation, the EU can achieve a resilient and sustainable energy future.

# Annex 1

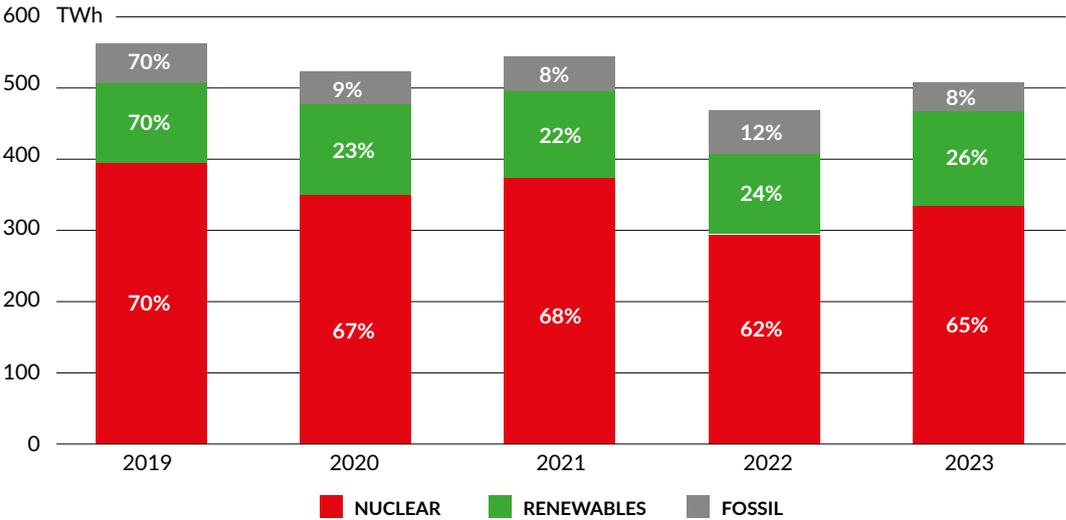
## Lessons from the energy crisis

### 1. Weaknesses of the energy system

**High reliance on a single supplier:** The energy crisis revealed significant systemic risks associated with a heavy dependence on single suppliers and specific energy sources, notably Russian imports. In 2021, the EU’s reliance on Russia for energy was stark, with the bloc importing substantial amounts of Russian gas (42% of EU imports were Russian gas), crude oil and oil products (32%), and coal (50%) (Figure 1).

**High reliance on a single source of energy:** Nuclear energy provides about 70% of France’s electricity supply. In 2021, France’s nuclear power sector faced significant operational challenges, including maintenance delays and technical issues, which impacted electricity output. Plant outages led to a decline in nuclear generation, pushing output below the usual range (Figure 1). Consequently, France was forced to rely on energy imports to meet its demands.

Figures 1: Electricity generation in France by fuel type 2019-2023, TWh and %; France’s electricity exports (2019, 2021) and imports (2022).

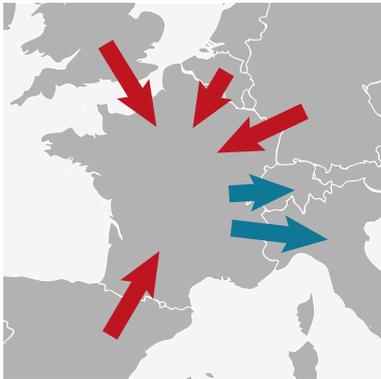


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2019 AND 2021 MEAN NET CROSS-BORDER FLOWS



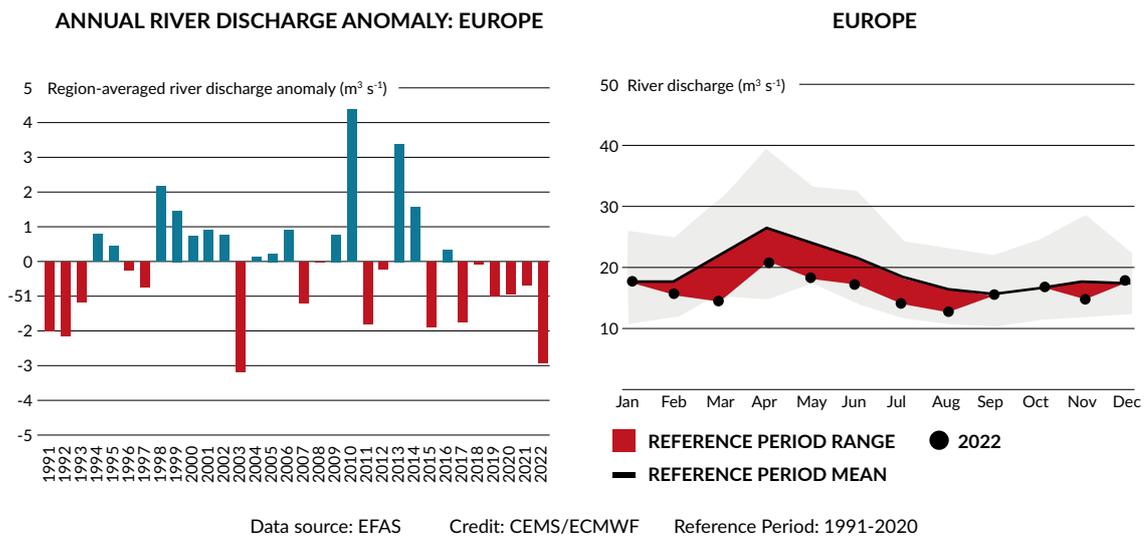
2022 NET CROSS-BORDER FLOWS



Source: Bruegel based on EMBER.

**Climate change:** The recent energy crisis in Europe exposed how climate variability can exacerbate existing vulnerabilities. In 2022, hydropower, which typically provides more than 10% of the electricity in the EU, saw a 20% decline in generation (compared to 2021), associated with widespread droughts. With river levels at historic lows (Figure 2) in 2022, Portugal stored less than half its average hydroelectric energy; Italian hydroelectric power plants produced 40-50% less electricity, even forcing a temporary plant shutdown in Piacenza. Additionally, the low river levels disrupted the cooling systems of power plants, resulting in decreased electricity production and reactor shutdowns along the Belgium-France border<sup>61</sup>.

Figure 2: Annual river discharge



Note: coloured areas indicate deviations from the average for the 1991 - 2020 reference period, with blue indicating higher discharge and red indicating lower discharge.  
Source: Copernicus. Climate change service.

## 2. Implications of vulnerability of the energy system

**Risk of insufficient energy volumes:** In the short term, the abrupt disruption of Russian gas supplies in 2021 placed the EU in a challenging situation, making it difficult to replace the lost volumes quickly. A gas shortage ahead of winter posed a significant risk of insufficient energy volumes irrespective of gas price considerations. Consequently, the EU sought new markets and gradually diversified its gas imports, incorporating sources among others from Oman, Egypt, and Angola.

**Large monetary cost:** Record-high natural gas, electricity, and oil prices have led to double-digit inflation in many European countries<sup>62</sup>. This situation has been especially challenging for lower-income households, as energy bills represent a relatively more significant portion of their income. To help alleviate this burden, European governments have allocated €651 billion since September 2021 to offset the effects of rising energy prices<sup>63</sup>.

**Political risks:** Dependence on Russian energy impacts policy towards Russia. Governments may find it challenging to support sanctions or take stances against Russia without jeopardising their energy supplies, while non-transparently priced Russian energy made available to specific partners allows Russia to stealthily influence important interest groups in an importing country. Hence, some countries did not seek to reduce dependence and now continue to purchase Russian oil and gas.

61 <https://www.nature.com/articles/s41561-024-01559-2>

62 <https://ec.europa.eu/eurostat/documents/2995521/15725179/2-18012023-AP-EN.pdf/e301db8f-984c-27e2-1245-199a89f37bca>

63 <https://www.bruegel.org/dataset/national-policies-shield-consumers-rising-energy-prices>

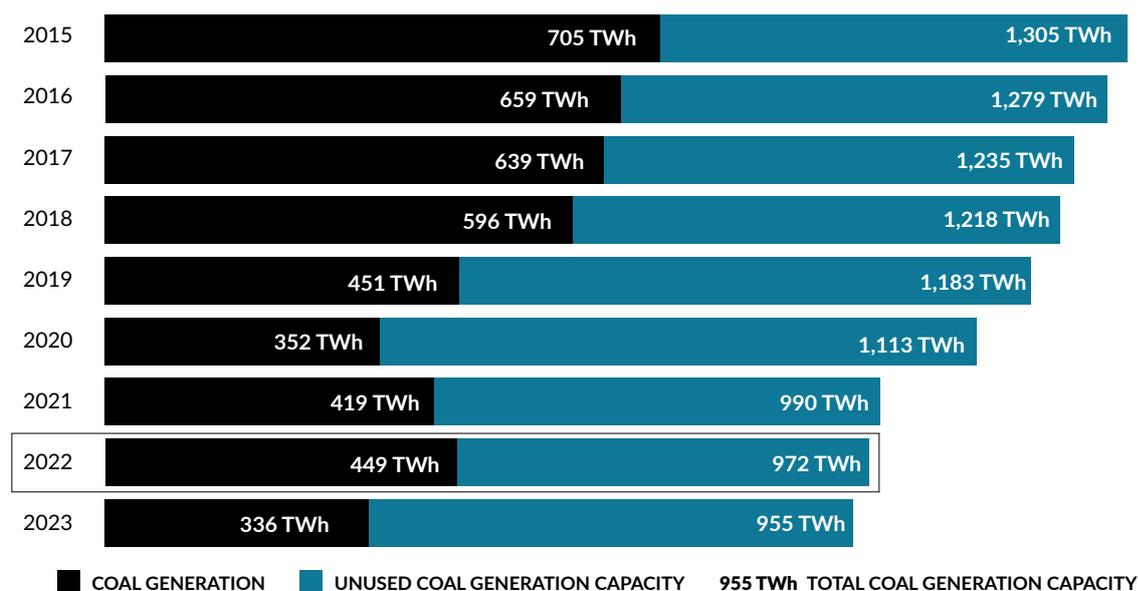
### 3. Factors to consider for effective crisis management

**Data:** The crisis exposed a lack of available data on gas to assess energy dependency. While gas storage data in 2021 were available and instrumental in navigating the energy crisis, there was, for example, no data on individual countries' dependency on Russian gas imports (e.g., Austria reported zero dependencies at the beginning of the crisis). The same was true for information on energy demand by different consumer groups as well as the prices those consumers pay. The lack of available data hindered policy planning, crisis response, and market stability, as governments and stakeholders were unable to assess the risks or prepare fully for supply disruptions.

**Infrastructure:** The recent energy crisis underscored the critical role of having underused infrastructure, which allows for a crisis to be overcome more smoothly. Notably, regasification capacity utilisation rates saw a jump from almost 50% in 2021 to 70% in 2022, providing alternative gas supplies amid disruptions.

**Reserve capacity:** Reserve capacities, such as coal-fired power plants, were crucial at the height of the crisis. From 2015 to 2020, coal plants were gradually being phased out. Thereby, generation dropped twice as fast (-50%) as capacity (-23%) (Figure 3). In 2021/2022, this over-capacity came in very handy to buffer the shock from dropping gas, nuclear and hydro generation.

Figure 3: EU capacity of coal generation versus electricity generated.

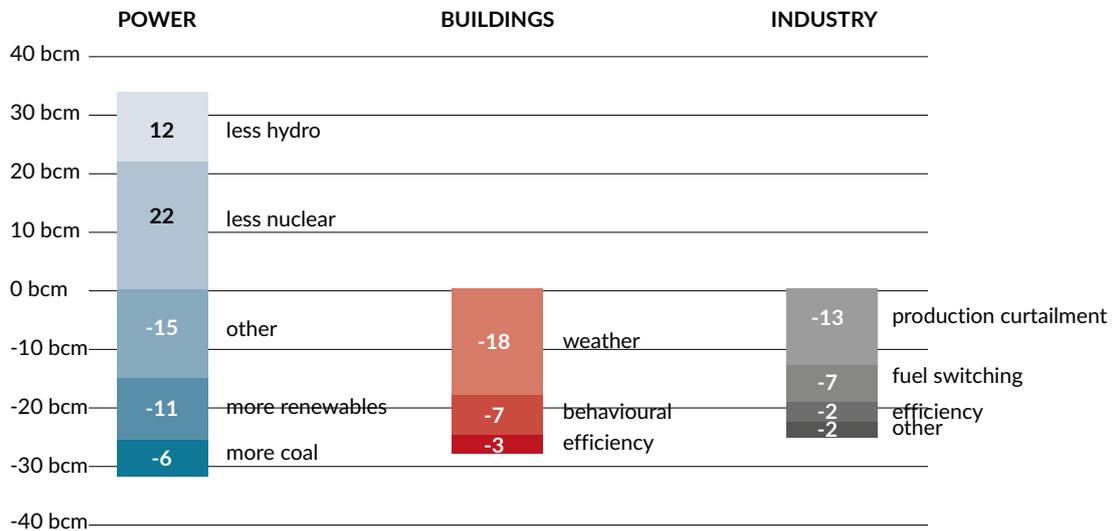


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Source: Bruegel on EMBER.

**Demand reduction :** Demand response measures led to significant reductions in gas consumption (Figure 4). Fuel switching, especially in the power sector, substituted natural gas with coal and renewables, and industries substituted gas with oil. Simultaneously, increased behavioural change and energy efficiency in buildings and industry allowed for a further reduction in gas consumption. However, energy-intensive industries responded to the gas price shocks also by reducing production and importing gas-intensive intermediary products from outside the EU<sup>64</sup>.

Figure 4: Change in EU natural gas demand in power, buildings and industry, 2022 vs 2021, in bcm.

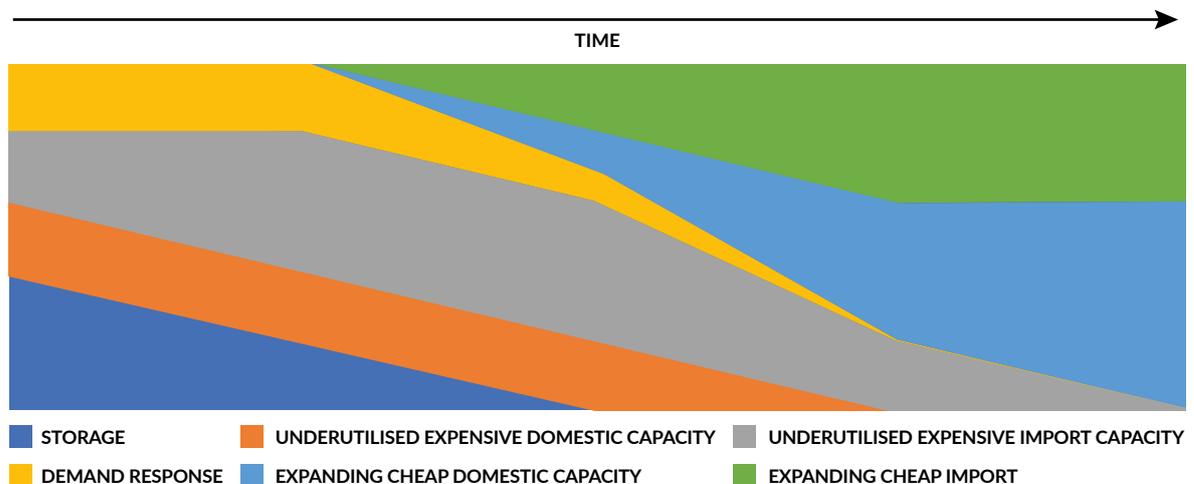


Source: Bruegel on IEA.

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**Value of time:** The crisis highlighted the importance of forward-looking policies to anticipate and adapt to sudden disruptions, ensuring energy system resilience. Investments in infrastructure, such as building new LNG terminals and expanding pipelines, along with securing contracts with alternative suppliers, requires time. For instance, Germany's first floating LNG terminal in Wilhelmshaven, which became operational in late 2022, was completed in record time, yet it still took nearly a year from conception to deployment. Simultaneously, with time, securing new LNG supplies mainly from the US but also from Egypt, Angola, and Oman allowed the EU to diversify gas imports and reduce its dependence on Russian gas, lowering Russian imports from nearly half in 2020 to 15% by 2023 and even less in 2025<sup>65</sup>. Lastly, sufficient storage levels ahead of winter could be a significant buffer against sudden supply shocks. Had policies in infrastructure development, supply diversification, and sufficient storage levels been implemented earlier, the economic strain during the crisis could have been significantly reduced.

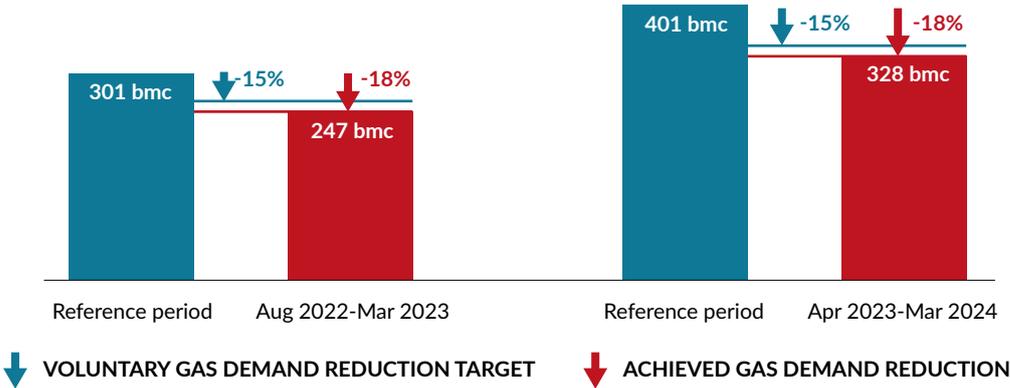
Figure 5: Conceptual illustration of the value of time in response to an energy crisis.



Source: Bruegel.

**EU coordination:** Despite the lack of preparation, markets and EU coordination allowed for balancing the system without supply disruptions and avoided forced rationing. The EU has set a voluntary target to reduce gas consumption by 15%. EU countries exceeded the target, reducing the combined EU gas demand by 18% (Figure 6), saving around 130 bcm of gas.

Figure 6: Gas demand reduction in the EU.



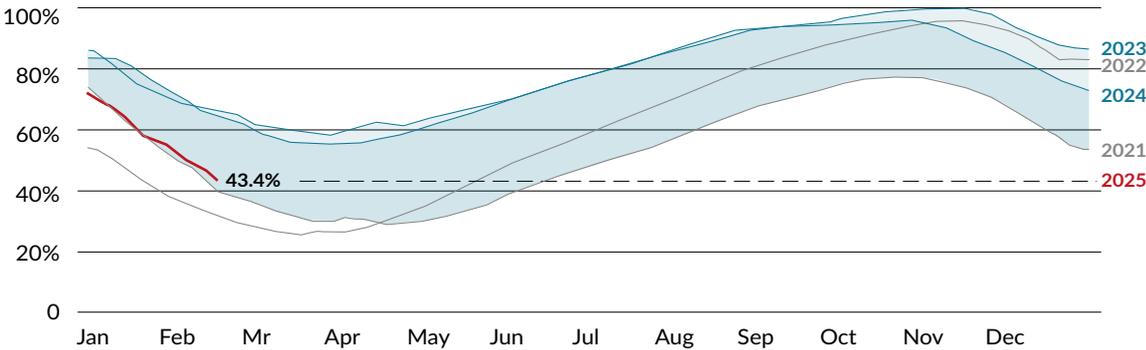
Note: The reference period corresponds to the same time frame averaged over the preceding five years.  
 Source: Bruegel on Eurostat. Gas reduction targets are outlined in RePowerEU.

In November 2022, the EU filled 95% of gas storage, surpassing the goal of 80%. In 2023, the target was increased to 90% by November but was already achieved in August<sup>66</sup>.

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Since 2021, the EU has also diversified its fossil fuel imports. EU sanctions banning seaborne imports of Russian crude oil, refined petroleum products, and coal have led to a more diversified supply. The rapid diversification was helped by very liquid global markets for these fossil fuels. This did cut both ways: the EU was able to switch to non-Russian supplies, while Russia was able to switch to non-Western consumers (e.g., India).

Figure 7 : EU gas storage levels 2021-2025



Source: European Commission on GIE

66 [https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/repowerEU-affordable-secure-and-sustainable-energy-europe\\_en](https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/repowerEU-affordable-secure-and-sustainable-energy-europe_en)

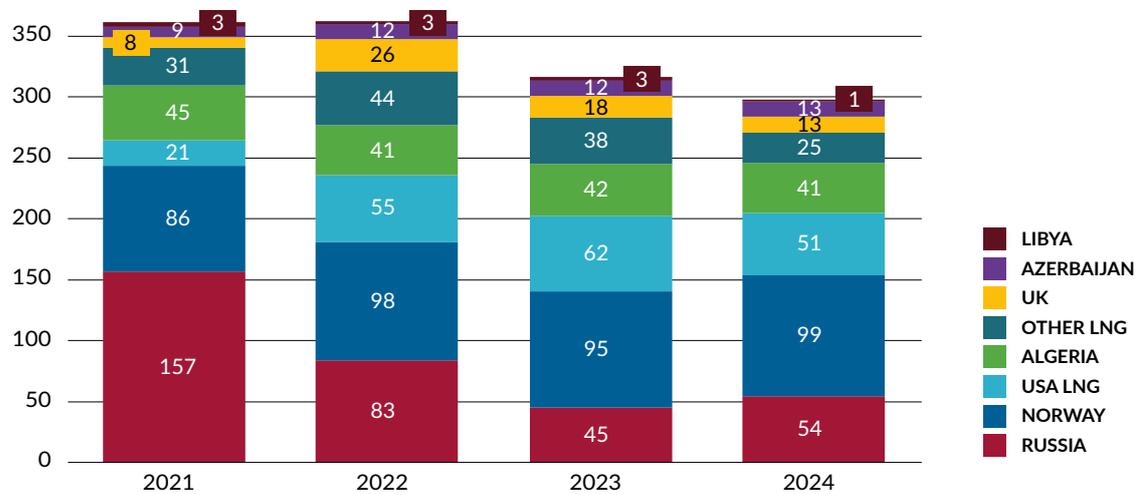
## Annex II

### Main suppliers of energy resources and technologies to the EU

#### Natural gas

Between 2020 and 2023, the EU cut Russian gas imports from 50% to 15%. Norwegian gas via pipelines and US LNG were the largest sources of EU gas imports. LNG imports from Egypt, Angola, and Oman, as well as piped gas from Azerbaijan, further diversified the EU gas import mix. However, in the first three quarters of 2024, Russian imports overtook US LNG as the second-largest source, making up 18% of EU imports<sup>67</sup>.

Figure 1: Natural gas supply in the EU, 2020, 2022, and 2023, bcm.



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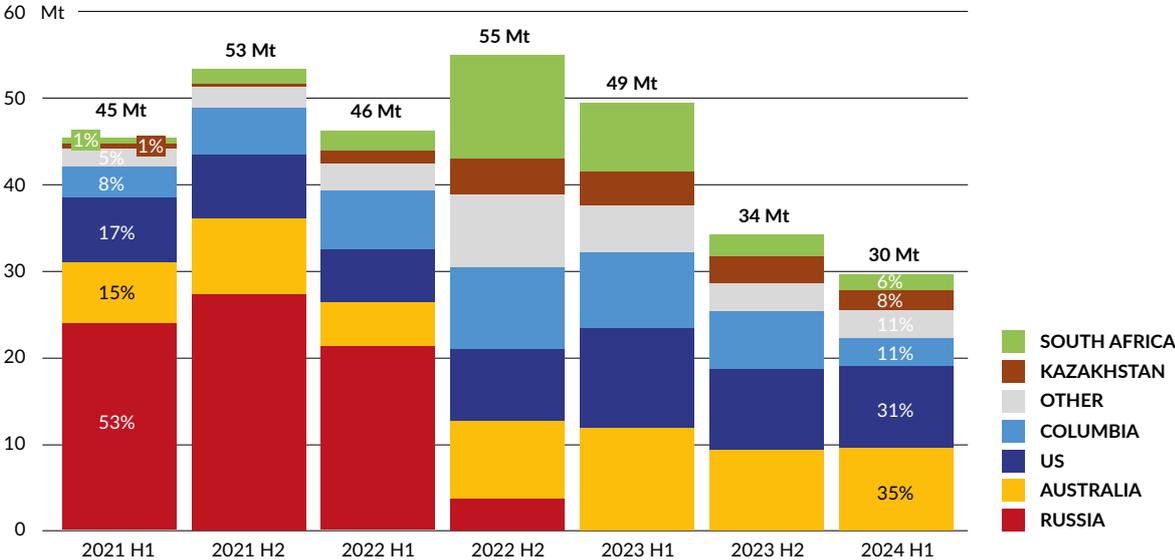
Source: Bruegel.

#### Coal and oil

In the first half of 2021, Russia was the largest source for coal (53%), crude oil (17%), and diesel (52%) imports to the EU. In December 2022, the EU imposed an embargo on crude oil and, in August 2022 on coal and in February 2023 on oil products (including petrol and diesel). As a result, EU imports from Russia were replaced by supplies from a range of countries.

Between the first half of 2021 and the first half of 2024, Russian coal imports (53% of overall EU imports) were replaced mainly by larger import volumes from Australia and the US but overall coal imports decreased.

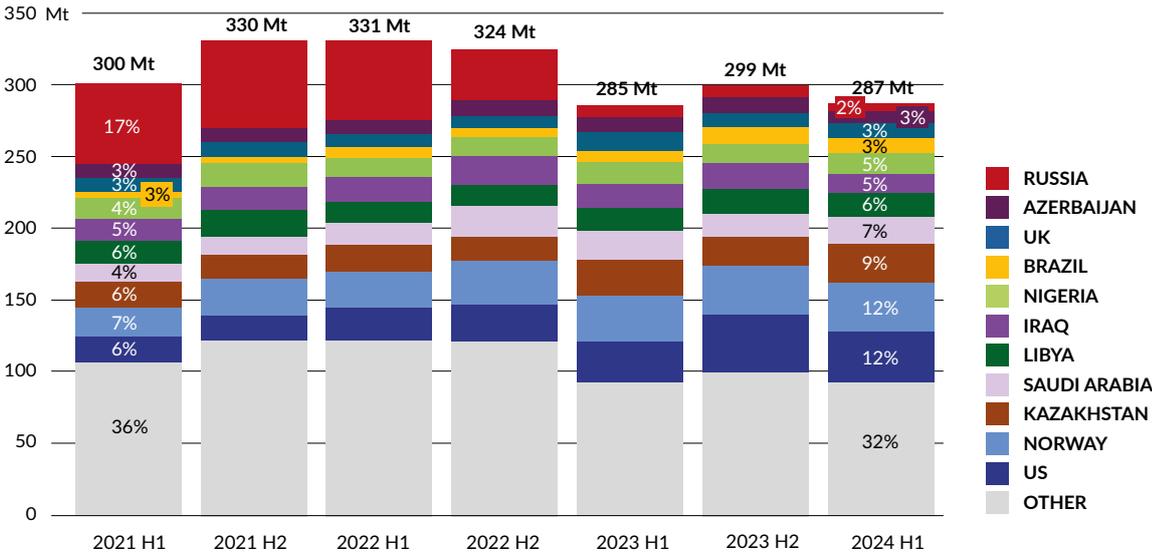
Figure 2: EU coal imports, 2021 H1–2024 H1, million tonnes (Mt).



Note: Code 2701: Coal.  
Source: Bruegel on Eurostat.

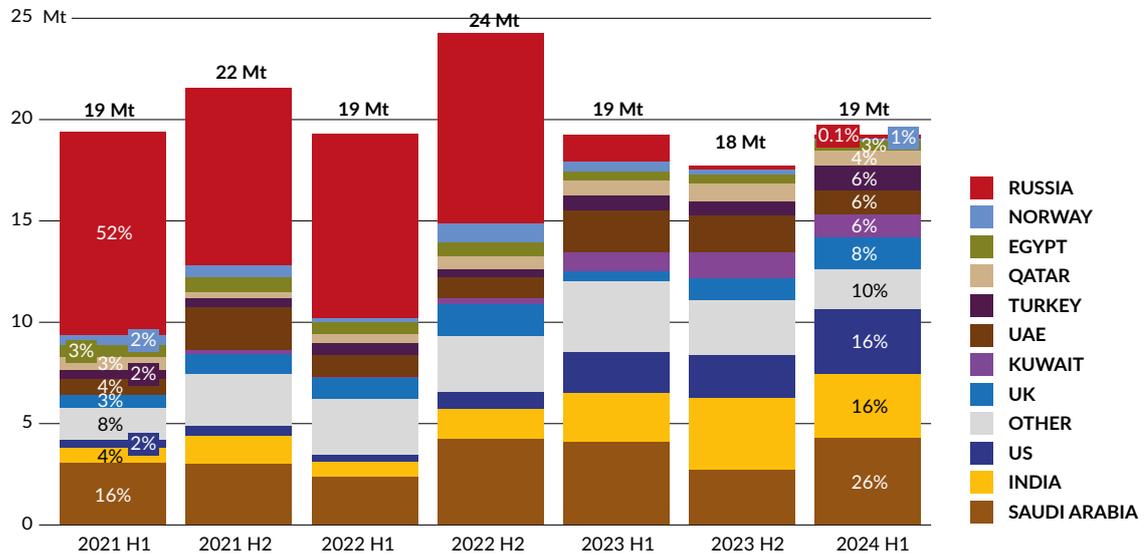
Russian crude oil's share of total EU imports dropped from 17% to 2% between the first half of 2021 and 2024. Russian volumes were replaced by all other suppliers, most significantly the US, Norway, Kazakhstan, and Saudi Arabia. Similarly, with diesel, Russian volumes (52% in the first half of 2021) were replaced by Saudi Arabia, India, and the US in the first half of 2024.

Figure 3: EU crude oil imports 2020 H1–2024 H1, million tonnes (Mt).



Note: Code O4100\_TOT: Crude Oil.  
Source: Bruegel on Eurostat.

Figure 4: EU road diesel imports 2020–2024 H1, million tonnes (Mt).



Note: Code O46711: Road diesel.  
Source: Bruegel on Eurostat.

### Heterogeneity among EU countries

All EU member states are import-dependent, especially on oil imports and natural gas. However, energy import dependencies vary by share and origin. For example, the Netherlands, Greece, Belgium, Ireland, and Spain are over 80% reliant on energy imports, while Estonia, Sweden, Bulgaria, and Romania are less than 40% dependent on energy imports (Figure 5).

The highest import dependencies for natural gas are across landlocked Central European countries—Austria, Slovakia, and Czechia—while Romania (18%) and Denmark (28%) are the lowest.<sup>68</sup>

<sup>68</sup> Estonia has the lowest import dependency in the EU because its electricity generation is based on domestic oil shale (which will be gradually decommissioned due to high CO2 emissions in the coming years) but remains highly dependent on oil and gas imports.

Figure 5: Energy import dependency by fossil fuel type and EU country in 2023, %<sup>69</sup>.

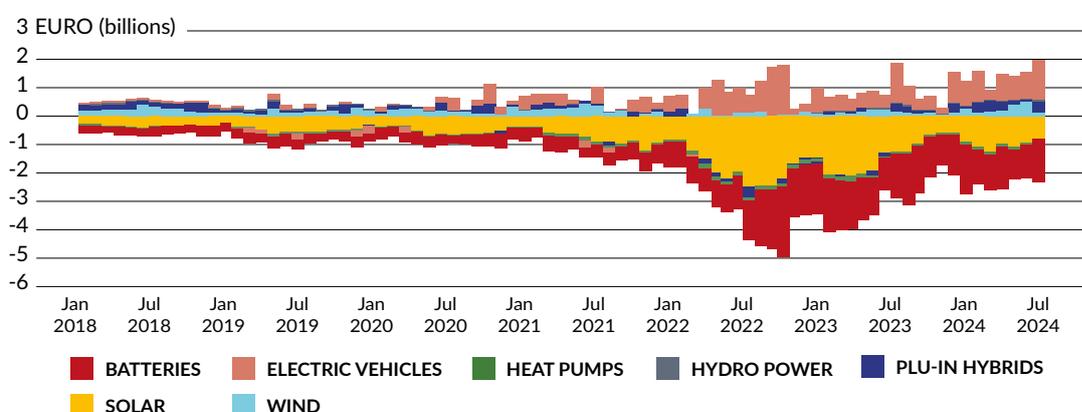
	Total	Solid fossil fuels	Oil and petroleum products	Crude oil
Malta	98%	0%	100%	0%
Cyprus	92%	42%	103%	0%
Luxembourg	91%	100%	100%	0%
Ireland	78%	86%	99%	97%
Belgium	76%	102%	100%	100%
Greece	76%	-9%	98%	99%
Italy	75%	96%	89%	93%
Netherlands	70%	102%	93%	98%
Spain	68%	72%	99%	99%
Lithuania	68%	90%	96%	98%
Portugal	67%	81%	99%	100%
Germany	66%	49%	94%	98%
Hungary	62%	25%	89%	86%
Austria	61%	102%	96%	94%
<b>EU</b>	<b>58%</b>	<b>41%</b>	<b>95%</b>	<b>96%</b>
Slovakia	58%	90%	105%	104%
Croatia	56%	109%	83%	65%
Slovenia	49%	27%	99%	0%
Poland	48%	5%	97%	97%
France	45%	75%	98%	99%
Czechia	42%	15%	99%	99%
Bulgaria	40%	5%	102%	100%
Denmark	39%	108%	50%	60%
Latvia	33%	87%	99%	0%
Finland	30%	70%	87%	98%
Romania	28%	13%	71%	72%
Sweden	26%	96%	100%	99%
Estonia	3%	269%	81%	0%

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Source: Bruegel on Eurostat.

The EU relies heavily on imports of clean technology, particularly PV and batteries, to support its energy transition. China dominates the supply chain, accounting for a significant share of imported solar modules and lithium-ion batteries. While these imports enable rapid deployment of renewable energy and electrification, they also raise concerns about supply chain resilience and strategic dependencies.

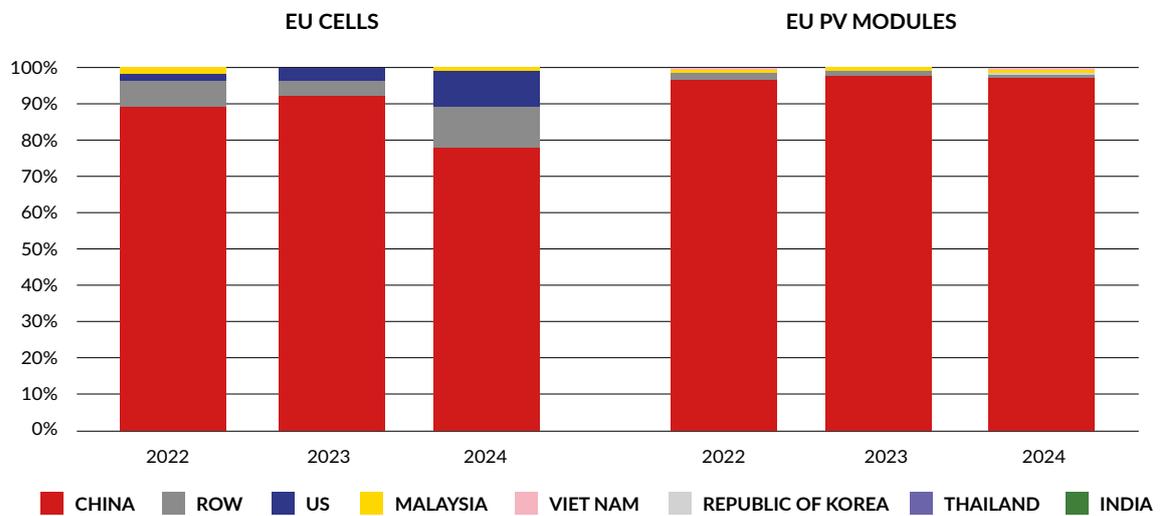
Figure 6: Clean tech trade



Source: Bruegel

<sup>69</sup> Import dependency can exceed 100% when a country imports more energy than it consumes, often due to re-exporting or stockpiling reserves. This situation is common in smaller nations that serve as energy hubs.

Figure 7: Share of imports of PV and battery cells to the EU



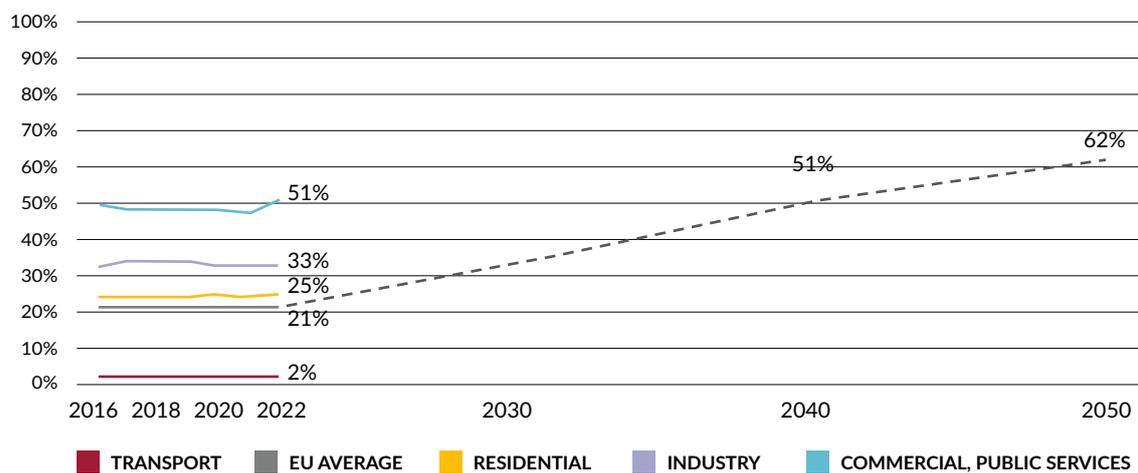
Source: Bruegel

### Electricity in final energy consumption grows slowly

European energy and climate policy require growing electrification of energy demand. However, the share of electricity in final energy demand has been fixed at 21% since 2016. The least electrified sector is transportation, at just 2% (Figure 7). This is concerning, as modelling work from the European Commission suggests the share of electricity in final energy demand should grow to 33% by 2030, 51% by 2040, and 62% by 2050 (2040 impact assessment).

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Figure 8: Electricity in final energy consumption in the EU, 2016-2022 and 2030, 2040 and 2050 targets.



Source: Bruegel based on Eurostat.







# Towards sustainable energy security Europe needs a new strategy now



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