

13. The European Union's energy security based on renewables

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Abstract: Energy security is considered through the EU's efforts to reduce dependence on imported fossil fuels by expanding renewables. The chapter reviews energy-security concepts, import-dependency patterns, post-2022 shifts in supplier relations, EU climate policy and supply chains for solar photovoltaics and wind turbines. Renewable energy can reduce exposure to imported gas, oil and coal, but it does not automatically remove dependency risks. Photovoltaic production is dominated by Chinese firms across raw materials, components and assembly, creating a new vulnerability for Europe. Wind energy offers a stronger European position because EU companies remain important turbine producers and assemblers. The chapter points to a broader resilience agenda: domestic technological capacity, supplier diversification, grid expansion, storage, recycling and sustainable lifecycle management must accompany renewable deployment.

Keywords: renewable energy sources, European Union, energy security, energy dependency.

Introduction

Energy security has traditionally been associated with ensuring stable access to energy resources at acceptable prices. For the European Union, however, this objective has become increasingly complex due to its high dependence on external suppliers, geopolitical instability and the need to reconcile security of supply with climate objectives. The transition towards renewable energy sources is therefore not merely an environmental transformation, but also a strategic process aimed at reshaping the foundations of the European energy system. At the same time, the shift away from fossil fuels does not necessarily eliminate external dependencies. Instead, it may alter their structure by increasing the importance of raw materials, components or supply chains. This issue is particularly visible in renewable-energy industries, where the EU's presence differs considerably across sectors. The aim of this chapter is to assess the EU's position in strengthening energy security through the devel-

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opment of renewable energy and to indicate challenges. Particular attention is devoted to the structure of selected renewable-energy value chains and to the extent to which domestic production capabilities, supply diversification and technological capacity can contribute to reducing external vulnerabilities. The analysis also addresses the infrastructural and environmental challenges accompanying this transition.

13.1. Energy security

The European's (EU) energy system is continuously evolving due to the implementation of climate and energy policies at both the community and national levels. The growing accessibility of new energy production technologies and reliable supply appear to be achievable within the EU's borders in the near future.

Energy security is defined as the uninterrupted availability of energy in various forms, with acceptable quality and prices, while minimising the negative impact on the natural environment. The key components include the physical availability of energy and its economic affordability. These two aspects correspond to the fundamental dimensions of energy security: the geostrategic and economic. It is essential to note that energy security is multi-dimensional (analysed on many levels) and dynamic; it is shaped by market conditions and geopolitical situations (Gökgöz & Güvercin, 2018).

The geostrategic dimension refers to ensuring the continuous availability of energy in various forms, which consists of two components. The first is the geographic component, which includes the origin of energy resources, their transport routes, the level of risks associated with deliveries, the ratio of foreign to domestic sources, the location of production units within the energy system, and the distribution networks. The second component is strategic; this determines whether energy will be continuously accessible. There is no single universal method for developing an optimal energy security strategy or assessing the state of energy security in individual countries (Rabbi et al., 2022).

The economic aspect refers to the costs of sourcing energy resources and their prices. Economic security ensures that energy prices neither lead to energy poverty (the inability to meet energy needs due to excessive costs and/or market prices) nor hinder the socio-economic development of a given country. Several factors influence energy prices: market trends, political decisions, non-tariff trade policy instruments, production and distribution efficiency, and even infrastructure effectiveness (Yu et al., 2022).

13.1.1. Import dependency

First of all, it is important to emphasise that energy supply security does not equate to independence from energy imports. Otherwise, countries required to import energy for geographic or technological reasons would consistently experience energy insecurity and face economic development challenges. As Rokicki et al. (2023) note, import dependency consists of two crucial components: the supplier and the risk associated with energy supply (rather than the fact of importing itself).

The European Union has limited fossil fuel resources, making imports a necessity, as they account for over half of the EU's energy needs. In fact, all EU Member States are net energy importers (European Council, 2024a). Since the 1990s, dependence on natural gas imports has increased steadily, starting at approximately 50%. According to Eurostat (2024), this dependence rose to about 90% by 2019. Meanwhile, dependence on crude oil imports remained consistently high, exceeding 90% during the same period (Figure 13.1).

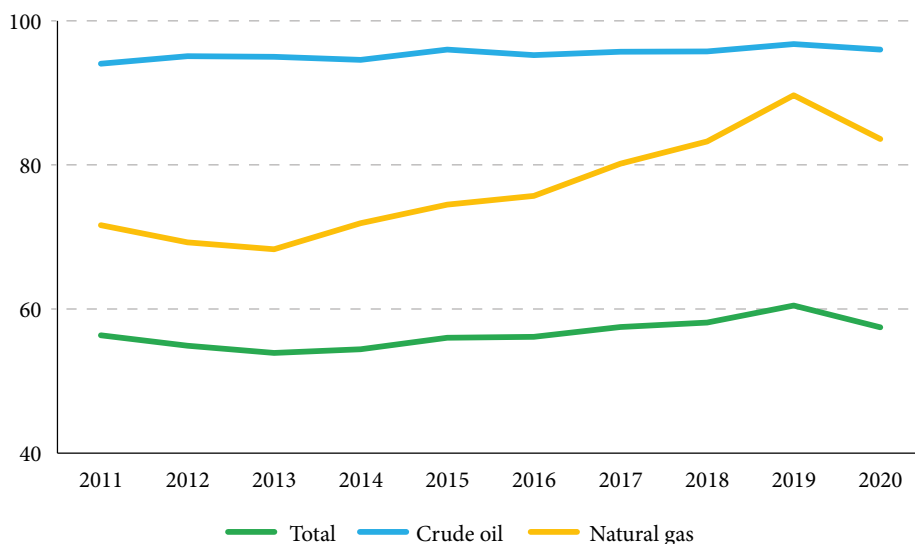


Figure 13.1. EU's energy import dependency (2011–2020)

Source: (Eurostat, 2020).

The European continent lacks substantial resources, and deposits of natural gas and crude oil are primarily exploited by Norway (a key supplier, though not an EU member) (Fischer, 2021). Since the 1990s, hard coal extraction has decreased fourfold due to the EU's regulations and policies, which is a sign of leaving fossil fuel-based energy behind. Despite this decline, its largest coal producer remains Poland (Eurostat, 2022a).

13.1.2. Directions of energy import in the EU

The issue of the EU's dependence on the supply of energy resources from beyond the Urals is significant. While Member States differ in their reliance on fossil fuel imports, at the beginning of the second decade of the 2020s, as many as 18 economies depended on a single supplier (Russia) for over 75% of their natural gas (Sharefedin, 2022). Regarding crude oil, the situation was the most critical along the EU's eastern external border, e.g. Poland 72%, Finland 84% (Demagog, 2022).

The outbreak of war in Ukraine triggered the introduction of political and economic sanctions aimed at Russia's economy, resulting in a reduction in the intensity of the EU's fossil fuel trade. Comparing the second quarter of 2022 to the same period in 2023, a significant drop in crude oil imports from Russia was recorded (a fall from 8.7% to 1.6%), leading to growth in purchases from other trading partners. Similarly, during the equivalent period, the EU halved its natural gas imports from Moscow, from 5% to 2.5%. According to Eurostat (2024a), the EU's new trading partners, by volume of imports, include:

- crude oil: Norway (13.7%), the United States (13.6%), and Kazakhstan (10.2%),
- natural gas: Norway (44.3%), the United Kingdom (17.8%), and Algeria (16.5%),
- liquefied natural gas: the United States (46.4%), Russia (12.4%), and Qatar (10.9%).

Fuel for the EU's nuclear power plants mainly originates from uranium mined in countries such as Kazakhstan (26%) and Russia (16.9%). After extraction, uranium is processed and enriched, often at facilities located in Russia, before being supplied as nuclear fuel. In recent years, the EU has sought to diversify its sources of nuclear fuel to reduce dependency on a single supplier (Eurostat, 2022b).

13.2. Renewables-based economy

The departure from exploiting deposits of raw materials, which for years were a crucial foundation of energy sourcing (e.g., hard coal or lignite), along with the growing dependence on external fossil fuel supplies, has led to the pursuit of a third path to achieve energy security. The EU has identified renewable energy sources (RES) as a primary pillar of its economic transition towards ensuring secure energy supplies while minimising negative environmental impacts (Potrč et al., 2021).

13.2.1. European climate policy

The Paris Agreement entered into force in 2016 after being ratified by at least 55 countries responsible for no less than 55% of global greenhouse gas emissions. It primarily engages the seven largest CO₂ emitters (China, the United States, the EU, India, Russia, Japan, and Brazil). This agreement represents a framework of actions aimed at mitigating global warming. Notably, the EU, on behalf of the community, along with all its Member States, signed and ratified the agreement. Subsequently, the European Climate Law, adopted in 2021, translated the climate goals for 2030 and 2050 into binding, legally enforceable regulations (European Council, 2024b).

The European Green Deal development strategy, introduced in December 2019 by the European Commission, is designed to combat natural resource depletion, ongoing climate change, and significant environmental degradation. Its vision is for Europe to become a climate-neutral, fair, and prosperous society with a modern, resource-efficient and environmentally friendly economy. By 2050, the European Union aims to achieve climate neutrality, assuming concurrent economic growth. Implementing this strategy involves redesigning the socio-economic system of the EU and incurring significant financial costs, enabling the EU to transform into a modern, competitive, and eco-friendly economy (Adamowicz, 2022).

13.2.2. Renewable energy sources

Renewable energy sources (RES) have undergone significant development over the last decade, becoming the second-largest source of electricity generation in the EU. Their share increased from 20% to nearly 40% between 2010 and 2020. At the same time, fossil fuels have lost their prominence in energy production thanks to the EU's climate policies and the shift towards a green economy (EMBER, 2021).

According to the EU's classification (Eurostat, 2024b), RES include:

- wind energy,
- solar energy,
- biomass and biogas,
- hydropower,
- tidal power and
- geothermal energy.

The driving forces behind green energy are solar power and wind energy. These two resources demonstrate the fastest year-on-year growth in electricity production in the RES sector within the EU. These two pillars are becoming fundamental to the energy security of the Old Continent (Olczak, 2020). A critical issue to consider is the EU's dependence on installation manufacturers.

13.2.3. Solar photovoltaics production market

China is the world leader in photovoltaic panels (PV) production, with its market share growing from 55% to over 84% within a decade (Conte, 2022). The competitive advantage lies at the very beginning of the supply chain – raw materials. China's investments in Africa have facilitated its access to these resources. Currently, the Red Dragon controls over half of the global raw materials (and processed materials) essential for solar panel production. China dominates nearly 90% of the market for components, while in the final stage, namely assembly, it commands a 70% market share (European Commission, 2020).

In contrast, the EU's involvement in solar panel production is minimal (Figure 13.2). Not only does its market share decline within each subsequent link in the chain, but the highest figure is a mere 6% in access to raw materials. The Achilles' heel of the EU's economy is, without a doubt, its zero contribution to component production (European Commission, 2020). The absence of domestic firms engaged in producing and supplying highly demanded products forces purchasing from foreign companies. Among the six largest PV systems producers, each is a Chinese enterprise (Statista, 2022a).

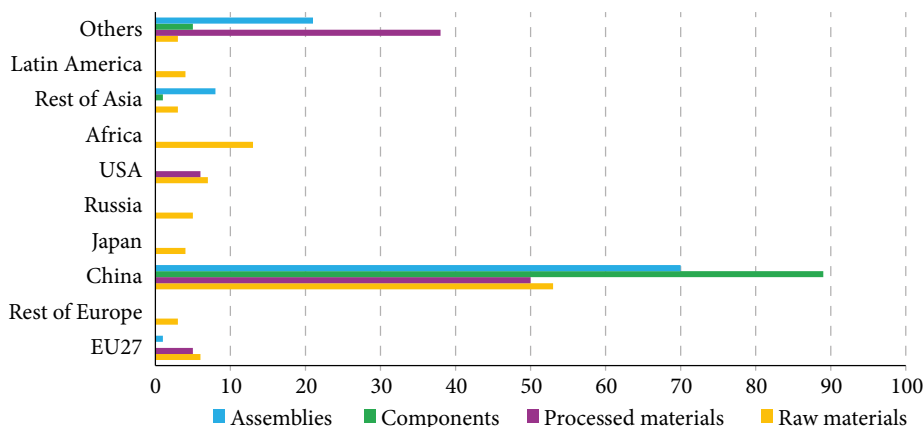


Figure 13.2. Solar PV: key players along the supply chain

Source: (European Commission, 2020, p. 39).

13.2.4. The wind turbine market

When analysing the wind turbine market (Figure 13.3), the trend runs contrary to what is observed in the PV market. While in the initial production stage, namely raw material access, China has achieved global dominance in the possession and control of deposits, its involvement diminishes, moving further up the supply chain. Though over half of the components are still produced in the Asian market, at the final stage – assembly – China's share is approximately 20% (European Commission, 2020).

Contrary to the EU's minimal presence in the PV panel supply chain, its participation in the wind turbine production process increases at each subsequent stage. However, access to raw materials is worse than in the previous case, as none exists. The EU's presence in subsequent links reaches double digits: e.g., 12% in materials and 20% in components. Nearly 60% of global assembly occurs within EU Member States (European Commission, 2020). Consequently, four of the six largest wind turbine manufacturers are European companies: the global leader, Denmark and three German firms. This provides a strong argument for the feasibility of ensuring energy security by orienting the EU economy toward wind energy. Nevertheless, Chinese companies are catching up. Following the top four, the fifth and sixth spots are occupied by one American and one Chinese company, respectively (Statista, 2022b).

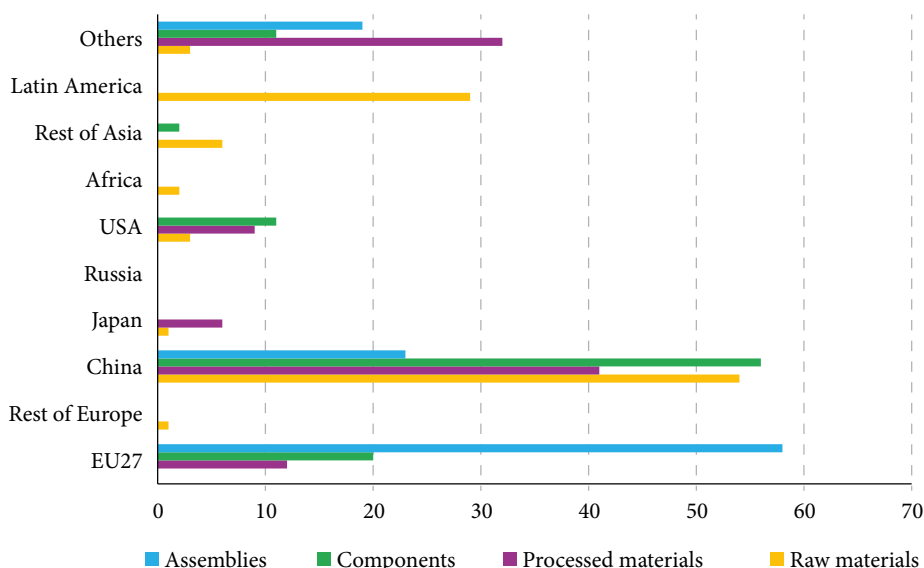


Figure 13.3. Wind turbines: key players along the supply chain

Source: (European Commission, 2020, p. 30).

13.2.5. Challenges

The lack of adequate infrastructure for transmitting energy generated from renewable sources is a significant challenge in the EU. While renewable energy production has increased, the transmission grid often struggles to accommodate fluctuating energy supply from sources like wind and solar. This mismatch leads to inefficiencies, energy losses, and bottlenecks, especially in areas where production exceeds local demand. Upgrading and expanding the grid and integrating energy storage solutions are crucial to ensuring the reliable and efficient distribution of renewable energy across the EU (European Council, 2023).

A pressing issue facing the renewable energy sector is waste management from installations that have reached or are nearing the end of their operational lifecycle. The more solar and wind farms in existence, the greater the volume of waste that must be managed and, where possible, recycled. While technological advancements have extended product lifespans with each new generation, the lifecycle of some of the first turbines and panels installed in the early 21st century has ended. Currently, the EU must manage over 200,000 tons of used equipment, and projections for 2050 anticipate a sixtyfold increase in waste from solar panels and wind turbine blades (Statista, 2024).

While recycling used solar panels and wind turbine blades presents significant challenges, it also opens up opportunities for innovation, new recycling technologies, and the establishment of emerging industries. A prime example is the Polish company Thornmann Recycling, which has developed cutting-edge technology to separate individual layers of bonded materials. Thornmann is part of the German Composite Cluster, which brings together firms from Germany, Austria, and Switzerland, amplifying shared knowledge's spillover effect. The recycled materials produced are repurposed to create drainage grates, cable duct covers, and sewer covers (Urban, 2022).

Conclusions

Climate change is driving societies to seek new energy solutions, as traditional methods of energy production from coal, gas, and oil are increasingly viewed as unacceptable. The EU's climate policy focuses on expanding the use of renewable energy sources and reducing reliance on external suppliers. Faced with high import dependency, the EU is investing intensively in RES to mitigate risks associated with international energy market instability.

Case studies highlight the dominance of Chinese firms in photovoltaic panel production, yet such reliance on major manufacturers creates new dependen-

cies and risks. Because photovoltaic panel production is heavily concentrated in China, the EU remains vulnerable to fluctuating market, political and trade conditions. To truly strengthen energy security, the EU should develop its local technology production and diversify its supply sources, thereby reducing dependency on single foreign suppliers.

The wind energy sector presents a far more favourable scenario, as European companies rank among global leaders, forming a foundation for energy security. The energy transformation aims to enhance energy security and protect the environment and contribute to achieving sustainable global development goals.

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