ART —— Analysis and Research Team

RESEARCH PAPER

Harnessing Wind Power

Navigating the EU energy transition and its challenges

Council of the European Union
General Secretariat

SEPTEMBER 2024

Introduction

As the winds of change sweep the globe, the European Union's push for renewable energy faces challenges amid rising geopolitical tensions. Meeting the targets of the European Green Deal and the Paris Agreement to limit global warming to 2.0 degrees Celsius will depend on the success of the energy transition[1]. With the energy sector accounting for 75% of the EU's greenhouse gas emissions, its transformation is essential for steering the continent towards climate-neutrality by 2050[2]. The EU has increased its target for energy coming from renewable sources by 2030 from 32% to 42.5%[3]. **Central to this transformation is wind energy**, which accounted for nearly 40% of the electricity generated from renewables in the EU in 2022[4].

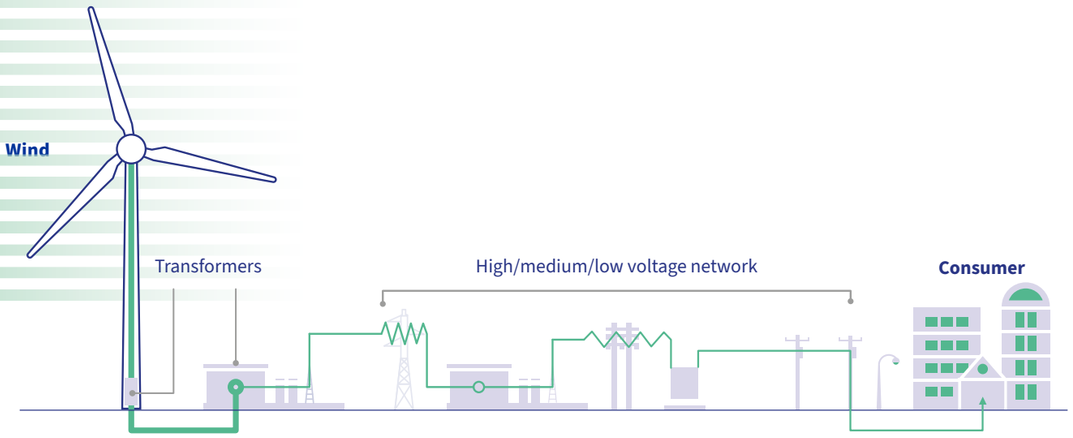
With **wind energy** expected to reach 50% of the EU's electricity mix by 2050[5], this sector is set to **become one of the EU's leading power sources**, playing a central role in reducing reliance on fossil fuels and enhancing energy security. However, the EU wind sector faces significant challenges, including **heavy dependence on China for critical raw materials** and permanent magnets, which are key components. These inputs are vital in manufacturing wind turbines and have drastically reduced wind energy costs. EU **reliance on Chinese materials now exceeds its prior dependence on Russian gas**, with the EU currently importing 100% of its rare earth elements from China compared to 45% of its gas from Russia before the invasion of Ukraine[6].

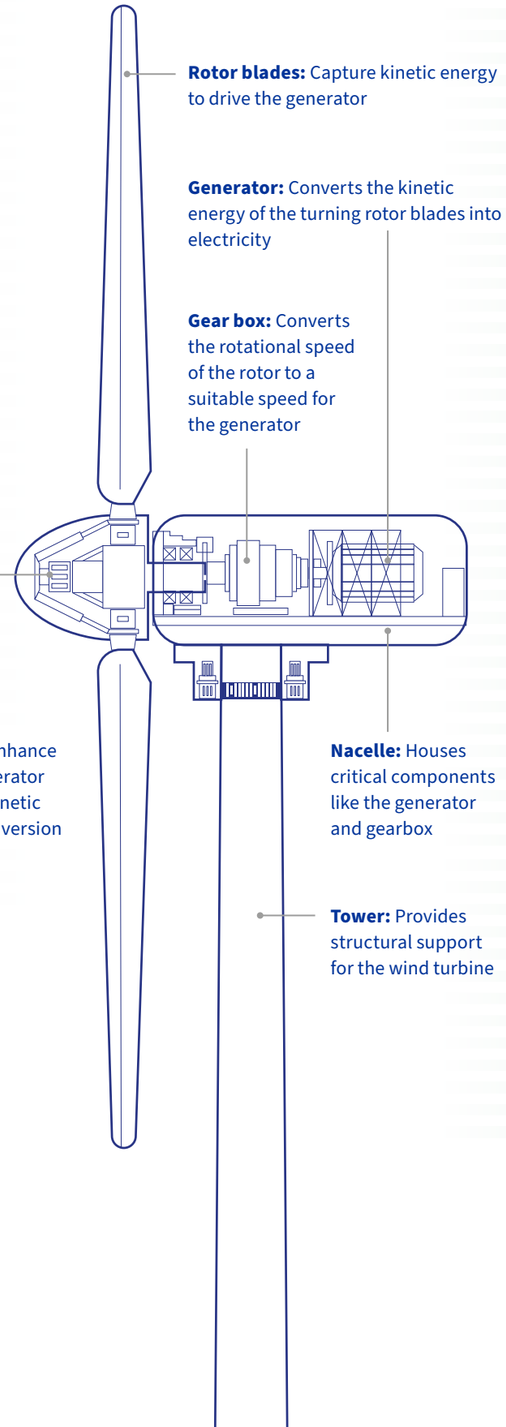
Russia's war of aggression exposed the risk of heavy reliance on external actors with competing interests. It revealed a strategic vulnerability for the EU, exposing **the need to reassess the EU's dependencies in critical sectors**. As the energy sector is responsible for powering the continent's growth, industry and economy, limiting the EU's exposure to geopolitical shocks is vital. The rapid loss of the EU solar photovoltaic market to China in the early 2010s saw EU companies lose out on a strategic market[7]. This development serves as a stark reminder of the need for the EU to **formulate a robust strategy that safeguards its interests** in the wind energy sector, preventing a similar decline in its competitive position.

This paper aims to delve into some of the vulnerabilities associated with the EU's energy transition, using **wind energy as a case study for broader issues affecting the renewable industry** as a whole. The first part assesses the current state of wind energy in the EU. The second part examines the obstacles the wind sector faces, particularly the dependency on China for critical materials and components, as well as other factors that might threaten the EU's ambitions. The third part illustrates possible strategies to mitigate these challenges, enhancing the EU's strategic autonomy and ensuring the success of its green transition.

Current landscape of wind energy in the EU

Wind turbines are renewable energy devices that harness the wind's kinetic energy and transform it into electricity. There are two main types of wind turbines: onshore and offshore. Onshore wind turbines are situated on land and are cheaper and easier to maintain. Offshore wind turbines are built in bodies of water; they are much larger and produce more energy than onshore turbines. Despite the difference in size, onshore and offshore wind turbines have similar components, as seen in the figure below. The manufacture of wind turbines requires extensive industrial capacity. This is partially due to their colossal dimensions, with the **tallest turbines reaching heights upwards of 200m[8], nearly matching the Eiffel Tower** in size. The industry trend shows that the height of wind turbines is bound to increase in the next decade to harness more wind energy with fewer turbines.





The EU's wind energy targets and sectoral contributions

In 2023 the EU has reached a total installed wind capacity of 220 GW (201 GW onshore, 19 GW offshore)[9]. **Six countries in the EU account for nearly two-thirds** of the total installed **wind power**. These countries are Germany (70 GW), Spain (30.6 GW), France (22.8 GW), Sweden (16.4 GW), Italy (12.3 GW) and the Netherlands (11.5 GW)[10]. Across the EU27, Denmark also emerges as a leading player, with the highest share of wind in its electricity mix[11]. The EU aims to reach 425 GW of wind power by 2030[12]. While installations are expected to accelerate towards the end of the decade, the EU is currently set to reach only 393 GW by 2030, falling short of its target due to a combination of factors.

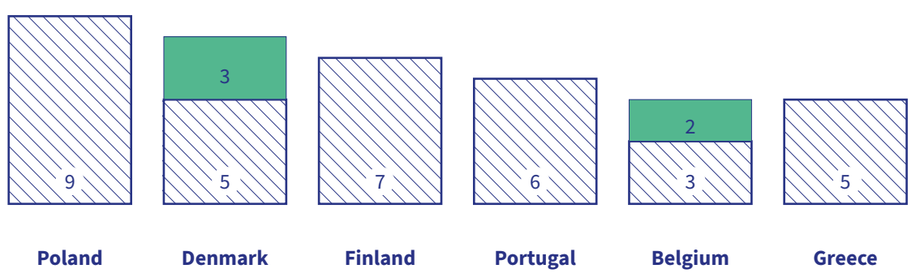
Although the expected growth in deployment is likely to prove insufficient to reach the EU's objectives, the **wind power sector is an important industry for the EU economy**, and its contribution is bound to increase significantly. The wind power industry employed 300 000 people as of 2022. With investments under REPowerEU, the **number of jobs in the sector is set to triple by 2030[13]**. In 2022 alone, using wind power and other renewables over traditional energy sources **saved consumers approximately €100 billion[14]**. The sector's economic importance is evident, but it also holds a strategic significance for the EU. Its growing role in the EU energy mix has allowed the EU to move away more steadily from Russian imports of oil and gas and boost its energy security.

State of EU manufacturing and main challenges

European companies hold 15% of the global market for manufacturing wind turbine blades but are dwarfed by Chinese producers, which account for 62%[15]. In the production of nacelles, European producers account for 17% of the market, with China representing 57% of global production. However, the Danish company Vestas emerges as one of the most prominent global producers of nacelles[16]. All in all, despite the dominance of Chinese manufacturers, EU companies are still recognised as world leaders in the sector and contribute to the EU's status as a net exporter in the industry[17]. However, there is a looming challenge: by 2026, it is projected that European demand for wind turbines will exceed the supply capabilities of EU companies[18]. This growing gap is combined with a steady decline in the EU's market share of wind turbine manufacturing at global level[19].

The decline in the EU's market share can be attributed to competition from China, which is the lowest-cost producer across all clean technologies. Manufacturing costs in US and EU facilities are 70 to 130% higher per unit output compared to China's[20]. European production costs are elevated due to the material-intensive nature of manufacturing, with materials accounting for around 60% of total costs[21]. China benefits from ample raw material supplies and cheaper labour costs than EU manufacturers.

Furthermore, with the 14th Five Year Plan targeting a 50% increase in renewable energy generation between 2020 and 2025[22], **Chinese wind turbine manufacturers receive generous subsidies** and other forms of government support. This makes it challenging for the EU industry to compete, which prompted the **EU to launch an investigation into subsidies** received by Chinese producers of wind turbines in April 2024, under the Foreign Subsidies Regulation[23].



Source: WindEurope

China is making a conscious effort to become the world leader in wind power, expanding its role across the supply chain. Lastly, with Beijing reaching its domestic wind power targets six years ahead of schedule, China's spare capacity is likely to be used for exports[24].

Consequences of Chinese growth for the EU wind power industry

Despite China's rise in the industry, global production of wind turbines remains localised, due to the complex logistics and economics related to shipping turbine blades and nacelles. It is **unlikely that cheap Chinese wind turbines will entering the EU's market as fully assembled imported products**. Nonetheless, the EU industry's declining competitiveness remains a serious issue, which has two more pressing consequences.

First of all, wind manufacturers fear that the rise of Chinese companies could see them enter the EU market and set up factories, thus competing locally. The European Commission highlighted this risk, reporting that Chinese producers are already bidding and winning auctions for plots of land/sea that are to be used to deploy wind farms in Member States[25]. The pressure to decarbonise and cut transition costs may lead Member States without local wind turbine production to favour cheaper Chinese bidders[26]. Chinese manufacturers currently offer wind turbines at prices up to 50% lower than European-made ones[27]. By producing in Europe, **China could even circumvent potential future EU measures** meant to protect the single market. Beijing is already considering this approach to shield itself from the electric vehicle subsidy probe launched by the Commission in October 2023. Chinese companies are proposing investments into local battery production in some Member States[28]. With Chinese companies making inroads into the EU market, the EU's strategic autonomy could be challenged[29], as Beijing could gain a stake in the European energy mix.

The second risk relates to manufacturers moving their capacity abroad. Manufacturing wind turbines is extremely energy intensive. With cheaper energy prices[30] and a more favourable business environment in the USA, **some EU wind manufacturing giants could be open to moving their activities abroad[31]**. There is also a risk that the race to decarbonise will trigger state-sponsored investments with the goal of buying up European producers. This could especially be the case for countries that have the financial means and aim to build up a stake in green manufacturing[32].

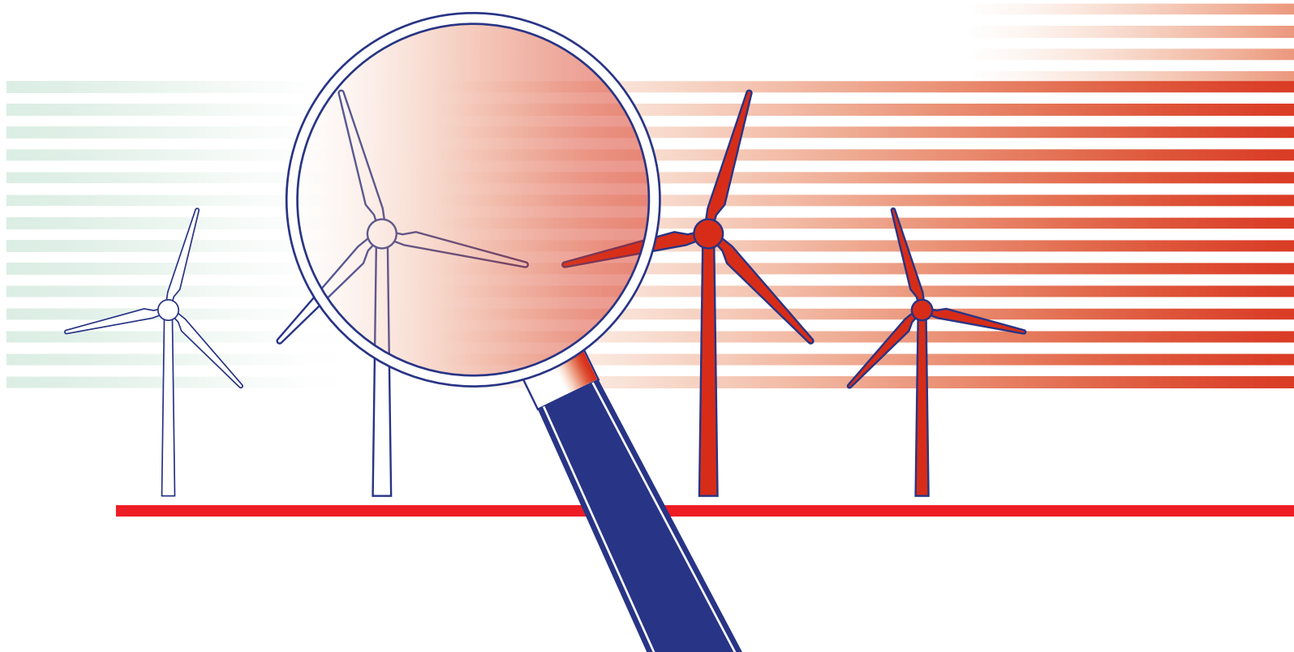
Innovation: the EU wind sector powers ahead

Notwithstanding the challenges the industry faces, the **EU wind ecosystem holds a significant advantage** over its competitors, as it is the **most active in patent filings[33]**. Countries in the European Patent Organisation hold the most applications, indicating that the region is world-leading in innovation. **Denmark and Germany lead the charge** in the development of offshore wind turbine towers that are less material-intensive[34]. Denmark also leads in innovations relating to wind turbine blades, accounting for 85% of inventions between 2017 and 2022, with a surge in patents related to recyclability[35].

Nonetheless, the EU **lacks market presence** in manufacturing **permanent magnets** and **depends on China for critical raw materials**. The next section explores the lack of capacity to produce this fundamental component and how this threatens EU ambitions.

Main obstacles to EU ambitions

The biggest obstacle to the EU's ambitions in wind energy is **dependence on China for critical raw materials**, which have been dubbed the **oil of the 21st century** due to their vital role in powering this century's energy transition[36]. Critical raw materials are essential in manufacturing components for wind turbines. **Without them, reaching climate neutrality by 2050** as outlined in the European Green Deal and the Paris Climate Agreement **becomes impossible**.

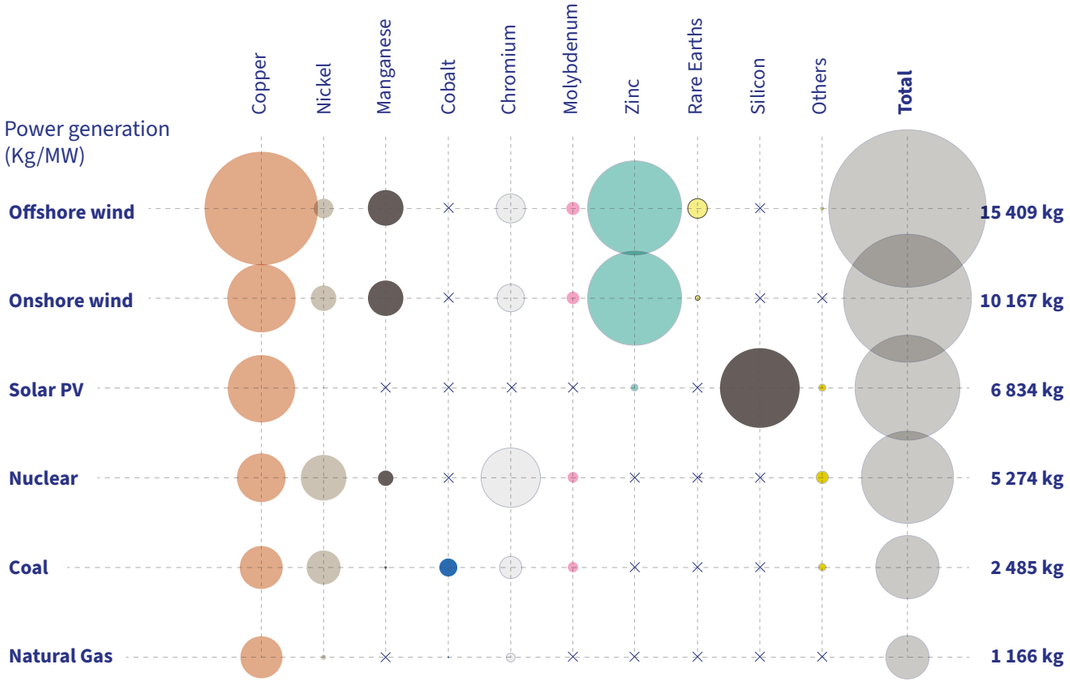


The importance of rare earths

Wind energy is the most material-intensive renewable source[37]. **Rare earth elements** are a group of critical materials used in wind turbines. They are the most essential type of rare earth elements and **are vital inputs to produce permanent magnets**[38], which are used in wind turbines to convert the kinetic energy generated from the turning of the blades into electricity. The ability of rare earth elements to maintain strong magnetic fields makes them crucial for rendering components efficient and reliable, guaranteeing the functioning of modern wind turbines, especially in offshore settings where large-scale installations are common[39]. These materials have made wind turbines more cost-efficient, reliable, and affordable[40].

China holds a quasi-monopoly position in the extraction and processing of rare earth elements as a result of targeted industrial policy spanning decades, beginning in the late 1980s[41]. Chinese leader Deng Xiaoping saw the potential of the materials, famously declaring that "the Middle East has oil, **China has rare earths**"[42]. Since then, China has overtaken previously dominant producers of rare earths in sheer volume of extraction and processing and climbed up the value chain, leading the sector in technological advancements.

Minerals used in selected clean energy technologies



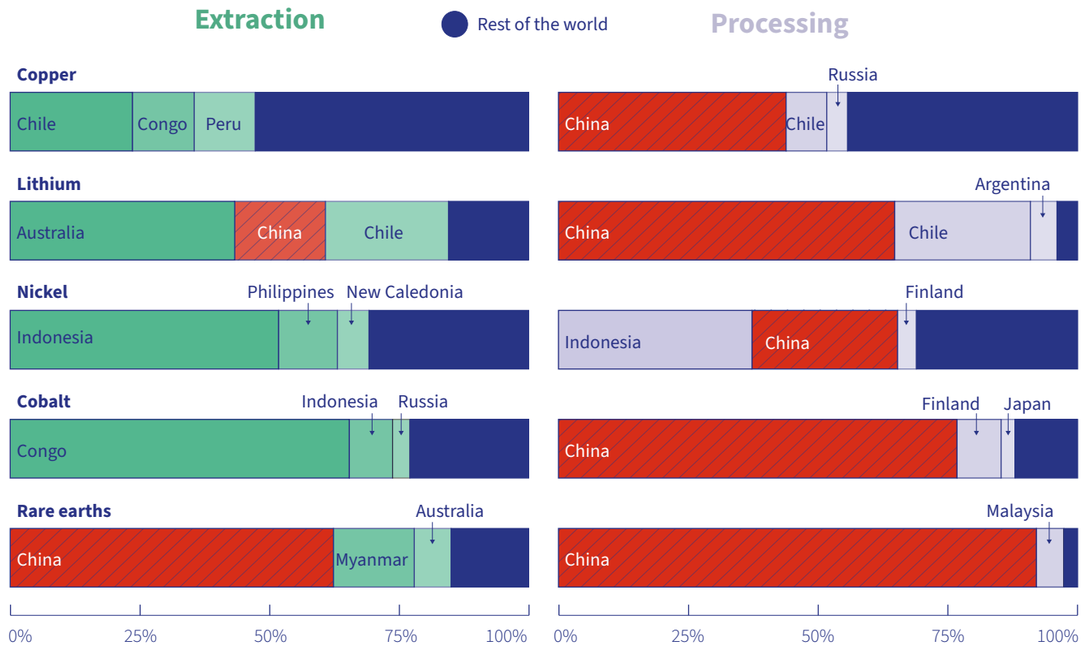
Source: IEA

Increased dependence on China

There are other materials required to produce these magnets, such as cobalt, nickel, molybdenum, and manganese, where China also holds a dominant position across the supply chain[43]. Without these vital inputs and access to permanent magnets, EU ambitions in wind power are threatened. Due to their unique properties, **substituting rare earth elements is extremely challenging**. Lack of access to the necessary critical raw materials would also increase the cost of wind energy, diminishing its cost-efficiency as a renewable energy source. Furthermore, the **trend** in patent applications in the wind sector indicates that the **usage of rare earth elements in the industry will rise**[44]. The increased number of installations and the growing dimensions of wind turbines will contribute to exponential growth in demand for the materials.

Currently, the **EU is 100% import-reliant on Chinese rare earth elements**[45]. China is also the main supplier of other vital critical raw materials for the production of wind turbines in the EU. China's dominance on the global stage is not limited to these vital inputs, as Beijing is also responsible for manufacturing 94% of permanent magnets globally[46]. The **EU is dependent on Chinese-produced permanent magnets** for 98% of its supply[47].

China leads in production of minerals needed for clean energy



Source: IEA

The risks of overreliance on China

The overwhelming dependence on China introduces multiple strategic risks.

Weaponisation of supply chains

The **risk of supply chain weaponisation** by China is not theoretical but **a strategic policy** that has been employed in the past by Beijing with significant impact. In 2010, during a territorial dispute with Tokyo over the Senkaku/Diaoyu Islands, China dramatically reduced its export of rare earth elements to Japan[48]. This action not only disrupted Japanese industries but also sent a clear signal to other nations about China's willingness to leverage its dominant position in the supply of critical raw materials. The risk is primarily of concern at the industrial level, as it can directly affect the manufacturing and operational capabilities of sectors dependent on these materials. **The growing influence of China** throughout supply chains for critical raw material provides Beijing with the **tools to limit the EU's access to vital inputs**. Should geopolitical tensions escalate, or economic disputes arise, the EU could find its wind energy ambitions hostage to Chinese policy decisions, undermining energy security and economic stability.

Market manipulation

China's **control over the majority of the global supply** of rare earth elements and permanent magnets grants it considerable **power to manipulate market prices and availability**, leveraging its quasi-monopoly position. This dominance enables China not only to set prices but also to deter the entry of new competitors into the market[49]. For the EU, this translates into **heightened risks for wind energy projects**, where sudden spikes in critical raw materials prices could derail budget forecasts and project feasibility. Furthermore, if EU firms attempted to enter the market, Chinese companies could artificially lower prices of permanent magnets to prevent competition. This volatility **complicates financial planning and investment in renewable energy infrastructure**.

Operational security

Chinese companies winning bids to build wind parks in Europe may pose a security risk to the EU's critical infrastructure, **challenging the EU's strategic autonomy**. Similar concerns have arisen in sectors other than energy, notably in telecommunications, where worries about reliance on Chinese technology sparked intense political discussions across Europe[50]. As is the case in telecommunications, certain **complex components found in wind turbines require maintenance**, software updates, and spare parts[51]. Given that wind turbines have a lifespan of 20-25 years, if Chinese manufacturers build wind installations in Europe, **dependence on Beijing could persist for many years to come**.

Geopolitical leverage

Dependence on China provides **Beijing with significant geopolitical leverage over the EU**, positioning it as a critical gatekeeper in Europe's efforts to reach its energy and climate goals. The strategic implications are significant. Reliance on critical imports from China forces the **EU to navigate a delicate balance** between internal policy goals and strategic autonomy aspirations, while also considering the risk of antagonising a key supplier[52]. This dynamic could constrain the EU's diplomatic action, particularly on issues where there is a divergence of interests with China.

The strategic implications of these dependencies are profound. They not only threaten the pace and scale of the EU's transition to renewable energy but also **expose the EU's strategic industries to the consequences of decisions made by non-EU actors**.

Other obstacles to EU wind ambitions

While not the focus of this paper, there are other obstacles in addition to dependence on Chinese critical raw materials that affect the EU's wind energy ambitions, such as issues surrounding lifespan, recycling, and NIMBYism (local opposition to developments, epitomised in the phrase 'not in my back yard').

Wind turbines have a lifespan of 20 to 25 years[53]. This r**elatively short lifespan** stems from the force of the wind, which often exceeds what the turbines are designed to handle. Over time, this increases the need for mechanical maintenance, which stops being economical after the turbine's designed lifespan.

Wind turbine blades are made of **composite materials, which are very difficult and costly to recycle**. The majority currently end up in landfill sites. Around 200 000 tonnes of turbine blade waste materials are expected to have gone to landfill by 2034[54]. Some wind turbines are burned as fuel, but the energy output is rather small and inconsistent. Increasingly, new methods of recycling old wind turbines are emerging, such as using old parts in architecture. Some examples include the Wikado playground[55] in Rotterdam and bike shelters in Denmark[56].

Lastly, **NIMBYism and environmental concerns** complicate both the establishment of wind farms and the opening of new mines to address critical raw materials dependencies[57]. Local populations often oppose these initiatives because they perceive them negatively and are worried about potential health impacts. Environmental concerns include habitat loss, collision risks, and noise pollution, affecting both human and animal populations[58].

All in all, the EU's wind energy ambitions face various obstacles which require a **multifaceted set of measures geared towards safeguarding the EU**'s energy future.

Permanent magnets manufactured globally:

China 94%

Rest of the world 6%

Measures to secure the future of EU wind energy

A comprehensive approach is needed to address the multifaceted obstacles to the EU's wind power ambitions. Several measures could help mitigate these risks.

Diversification of supply sources

Tackling reliance on Chinese materials requires **diversifying supply sources**. The EU has pursued this objective through partnerships with mineral-rich countries to reduce its dependence on single actors[59]. These partnerships also establish a framework for cooperation, outlining mutual expectations. This approach provides an **opportunity to re-establish the EU's commitment to sustainability** and ethical practices, by including green measures and objectives. Recent agreements between the EU and Zambia, the Democratic Republic of Congo and Angola not only increase access to raw materials, but they also reflect a shared commitment to the environment and local communities[60].

The EU has also signed Memoranda of Understanding with Australia and Chile, two of the world's largest producers of copper and lithium[61]. Australia also mines rare earth elements. As in the EU support for mining is increasingly questioned, **fostering partnerships** with countries that have access to vast material sources and the willingness to mine would **fortify the EU's strategic autonomy**. Nonetheless, diversification remains a difficult task in the case of rare earths due to China's dominant position in extraction and processing[62].

The push for diversification reduces the need for new material extraction inside the EU. Engaging with international partners allows for the procurement of essential materials for strategic applications like wind turbines, supporting the EU's 2050 net-zero emissions goal. This is especially important as NIMBY attitudes are prevalent across the EU. By **engaging with a variety of global partners**, the EU is not just **securing its supply chains** but also fostering international collaboration and market stability at a global level, both of which are key pillars for a sustainable and competitive future.

Strengthening the EU business environment

Effectively advancing wind turbine development across the EU requires a holistic approach. This involves accelerating permit-granting procedures for net-zero manufacturing projects, fostering closer ties between industry and education, and safeguarding the internal market from unfair competition. Aligned with the EU's renewable energy targets, these measures could promote green economic growth and job creation within Member States.

Expediting and streamlining permit-granting procedures could accelerate the deployment **of new wind parks**, helping to meet 2030 renewable targets more efficiently and reducing lead times for new projects, thus enabling a faster response to energy needs[63].

Enhancing cooperation between the wind energy sector and higher educational institutions **would create a skilled workforce** tailored to the needs of the sector[64] as it expands rapidly.

Initiatives could include developing specialised academic programmes and vocational training that focus on the technical skills most needed in the industry. Strengthened ties between the industry and education could drive innovations in wind turbine technology and installation techniques, which will be vital for the sector's long-term sustainability and competitiveness at the global level.

Implementing measures to guard the internal market against unfair competitive practices by third countries, for example by enforcing anti-dumping policies and compliance with EU standards, could create a **more equitable business environment**[65]. Such an approach could encourage greater investment in technology development and infrastructure expansion, fostering a robust European industry that can compete globally without the threat of being undercut by unfair practices. Also, pursuing a model of open strategic autonomy allows European companies to benefit from global trade while mitigating its negative effects, supporting competitiveness through open markets, competition and a strong single market.

Alternative designs and recycling

To further tackle the issue of rare earth elements dependency in permanent magnet production, **promoting reuse and remanufacturing**, along with exploring **alternative magnet designs**, would minimise reliance on single suppliers.

Reusing and remanufacturing the permanent magnets used in wind turbines offers considerable strategic advantages. These practices extend magnet life and decrease the demand for new raw materials, reducing the EU's import reliance[66]. Remanufacturing magnets to nearly-new condition also supports the circular economy strategy, seeking to maintain the properties of the materials through multiple life cycles. Economically, these practices can reduce costs related to new material procurement and processing, making wind energy projects more cost-effective and financially viable. They would also **reduce exclusive reliance on imports** to source the permanent magnets needed for wind turbines.

In addition to maximising the lifecycle of current magnet technologies, there is a strong case for investing in the **development of alternative magnet designs that require fewer or no rare earth elements**[67]. Research into such alternatives includes developing magnet materials that substitute rare earth elements with more abundant and less environmentally damaging materials. However, alternative designs may be less efficient.

Lastly, such a strategy would also require **designing permanent magnets and turbine components for easy disassembly** and remanufacture. Magnets could then be easily extracted from the structure, and either directly reused or refurbished with minimal effort and cost[68]. Facilitating easier disassembly can significantly **enhance the feasibility of recycling programs**, supporting the industry's transition towards more sustainable practices. This would also help to protect the EU from geopolitical tensions and protectionism that could extend to critical technologies.

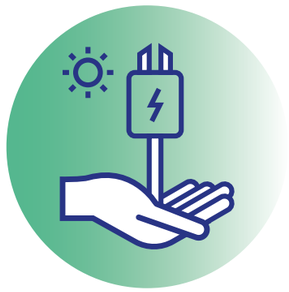
Through alternative designs and focusing on reuse and remanufacturing, the wind sector can reduce its dependency on Chinese critical raw materials and pioneer innovations in wind turbine design. These measures would **improve the sector's economic competitiveness**, paving the way for a more sustainable and circular future in renewable energy technologies.

Diversification of supply sources

Diversifying supply sources through global partnerships would reduce reliance on third countries, decrease the need for new material extraction within the EU, and promote international cooperation and market stability.

Strengthening the EU business environment

Accelerating permits for net-zero projects and enhancing cooperation between the wind industry and educational institutions could reduce lead times and create a skilled workforce. Measure to guard the internal market against unfair practices could ensure a more equitable business environment.



Alternative designs and recycling

Promoting the reuse, remanufacturing, and development of alternative magnet designs could reduce our dependence on Rare Earths Elements, support the circular economy, and reduce import reliance.

Conclusions

Wind energy is a cornerstone of the EU's broader climate and energy security objectives. However, the EU's path to energy independence and economic stability is **threatened by a strategic vulnerability**: an overwhelming reliance on Chinese critical raw materials, particularly in the production of essential components such as permanent magnets. This dependency exposes the EU to geopolitical risks and market manipulation.

A **holistic strategy** focusing on diversifying supply sources, strengthening the business environment in the EU, and fostering innovation through the development of alternative component designs could mitigate these risks. By forging robust international partnerships through MoUs, the EU can tap into a broader supply of resources, **reducing the risks associated with reliance on single-source suppliers**. Prioritising sustainability and adherence to ethical standards in these partnerships also aligns with the EU's commitment to green growth and fair-trade practices.

Streamlining approval processes, protecting companies against unfair competitive practices, and encouraging cooperation between industry, educational institutions, and academia can drive faster and more sustainable growth. **Promoting technologies that reduce reliance on rare earth elements** would not only diversify supply chains but also position the EU as a leader in global energy innovation.

In conclusion, these measures could steer the EU towards long-term energy security and economic resilience, preventing the strategic market losses witnessed in the photovoltaic sector over the past decade. They would **shield the EU from crises** stemming from supply disruptions and geopolitical tensions, and ensure a sustainable and competitive energy future. By moving forward with this approach, the **EU could safeguard its energy ambitions** while navigating the complex road ahead.

Endnotes

1 ‘Energy Transition’, CAN Europe.

2 Ibid.

3 ‘Renewable Energy Targets - European Commission’, European Commission, 20 November 2023.

4 ‘EU Wind Energy - European Commission’, European Commission, 2023.

5 ‘Getting fit for 55 and set for 2050’, ETIP Wind, 2021.

6 Alexander Brown, ‘Net-Zero Europe Risks a Heavy Dependence on China', Merics, 31 October 2022; ‘Leak: EU May Become as Hooked on China Batteries as It Was on Russian Energy’, Euractiv, 18 September 2023.18 September 2023.

7 ‘The EU Lost a Trade War with China 10 Years Ago. Has It Learned?’, POLITICO, 21 September 2023.

8 Nick Flaherty, ‘15MW Wind Turbine Is Record 260m High’, eeNews Europe, 12 February 2021.

9 ‘Wind Energy in Europe: 2023 Statistics and the Outlook for 2024-2030’ (WindEurope, February 2024), p. 9.

10 Ibid, p. 30.

11 Ibid.

12 Ibid, p. 8.

13 ‘EU Wind Energy - European Commission’, op. cit.

14 ‘How Much Money Are European Consumers Saving Thanks to Renewables? – Renewable Energy Market Update - June 2023 – Analysis, IEA, 2023.

15 ‘The State of the European Wind Energy Supply Chain’ (Rystad Energy & WindEurope, April 2023), p. 27.

16 Ibid, p. 27.

17 Giovanni Sgaravatti, Simone Tagliapietra, Cecilia Trasi, Cleantech manufacturing: where does Europe really stand?, Bruegel, 17 May 2023.

18 ‘The State of the European Wind Energy Supply Chain’ (Rystad Energy & WindEurope, April 2023), p. 29

19 Ahmed Abbas, ‘Chinese Manufacturers Dominating Global Wind Market | Enerdata, 18 January 2024, p. 7.

20 ‘Advancing Clean Technology Manufacturing’, IEA, May 2024, p. 9.

21 Ibid, p. 51.

22 Zhou Feng, Peng Linan, and Li Jie, ‘China’s 14th Five-Year Plans on Renewable Energy Development and Modern Energy System’, 5 September 2022.

23 Stuart Lau, ‘EU Launches Probe into Chinese Wind Turbines’, POLITICO, 9 April 2024.

24 ‘Advancing Clean Technology Manufacturing’, op. cit., p. 38.

25 Framework of measures for strengthening Europe’s net-zero technology products manufacturing ecosystem, European Commission Working Document, 10870/23, p.25.

26 Nina Chestney, ‘Chinese Wind Turbine Makers Involvement in EU Projects’, Reuters, 10 April 2024.

27 ‘EU starts investigation into Chinese wind turbines under new Foreign Subsidies Regulation’, WindEurope, 9 April, 2024.

28 Gregor Sebastian, Reva Goujon, and Alexander Meyer, ‘Pole Position: Chinese EV Investments Boom Amid Growing Political Backlash’, Rhodium Group, 29 February 2024.

29 Framework of measures for strengthening Europe’s net-zero technology products manufacturing ecosystem, European Commission Working Document, 10870/23, p.25.

30 Enrico Letta, ‘Much More Than a Market - Speed, Security, Solidarity’, April 2024, p. 62.

31 Ibid, p. 9.

32 Mark Segal, ‘KKR Launches $3 Billion Takeover Offer for German Renewable Energy Platform Encavis’, ESG Today, 15 March 2024.

33 ‘Offshore Wind Energy: Patent Insight Report’, IRENA, November 2023.

34 Ibid, p. 54.

35 Ibid, p. 54.

36 ‘Is the World Replacing Oil Dependency with Critical Minerals?’, World Economic Forum, 29 April 2024.

37 International Energy Agency, ‘The Role of Critical Minerals in Clean Energy Transitions’, IEA, March 2022, p. 26.

38 Kristin Vekasi, ‘Wind Power, Politics, and Magnets’, 18 November 2022.

39 Philip Andrews-Speed, ‘China’s Rare Earths Dominance and Policy Responses’, The Oxford Institute for Energy Studies, 2023.

40 ‘The Critical Role of Magnets In Wind Turbines’, Goudsmit UK, 3 August 2017.

41 ‘Does China Pose a Threat to Global Rare Earth Supply Chains?’, ChinaPo wer Project, 17 July 2020.

42 Ian Johnston et al., ‘Can Europe Go Green without China’s Critical Minerals?’, Financial Times, 20 September 2023.

43 Rodrigo Castillo and Caitlin Purdy, ‘China’s Role in Supplying Critical Minerals for the Global Energy Transition’, Brookings Institution, July 2022.

44 ‘Offshore Wind Energy: Patent Insight Report’, op. cit.

45 Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Study on the Critical Raw Materials for the EU 2023: Final Report, Publications Office of the European Union, 2023.

46 Roland Gauß et al., ‘Rare Earth Magnets and Motors: A European Call for Action’ (ERMA, EIT Raw Materials, 2021).

47 Ibid.

48 Keith Bradsher, ‘Amid Tension, China Blocks Vital Exports to Japan’, The New York Times, 23 September 2010.

49 Gauß et al., ‘Rare Earth Magnets and Motors: A European Call for Action’.

50 ‘Europe divided on Huawei as US pressure to drop company grows’, The Guardian, 13 July, 2020.

51 Joris Teer & Lukas Trakimavičius, ‘Here is how to protect the EU against Chinese electric vehicles and wind energy’, EUISS, 10 June 2024.

52 Jude Dempsey, ‘Europe’s Dangerous Dependence on China’, Carnegie Endowment, 4 April 2023.

53 ‘How Long Do Wind Turbines Last? Can Their Lifetime Be Extended?’, TWI Global, 2024.

54 ‘The Lifespan and Recycling of Wind Turbines’, Antala Ltd., 14 March 2022.

55 Bridgette Meinhold, ‘Wikado Playground Is Built From Recycled Wind Turbine Blades in The Netherlands’, Inhabitat, 27 March 2012.

56 Myrto Katsikopoulou I. designboom, ‘Denmark Is Repurposing Discarded Wind Turbine Blades as Bike Shelters’, designboom | architecture & design magazine, 27 September 2021.

57 Eric Onstad, ‘Some EU States Baulking at Streamlined Mine Permitting, Says Commissioner’, MINING.COM, 10 October 2023.

58 Joint Research Centre (European Commission), The Social Acceptance of Wind Energy: Where We Stand and the Path Ahead, Publications Office of the European Union, 2016.

59 Mike Schulze, ‘Security of Supply in Times of Geo-economic Fragmentation’, Stiftung Wissenschaft und Politik (SWP), 17 April 2024.

60 Theophilus Acheampong, ‘From Mines to Markets: How Africa and Europe Can Become Green Industry Partners of Choice’, ECFR, 24 April 2024.

61 ‘EU and Australia Sign Partnership on Sustainable Critical and Strategic Minerals, EEAS, 28 May 2024.

62 Decoding China’s dominance in global rare earth market, NS Energy, 25 October 2023.

63 ‘Wind Energy Permitting Is Improving but Governments Still Have Work to Do’, WindEurope, 8 February 2024.

64 Carlos Martin Rivals, ‘We Must Empower the Offshore Wind Sector through Training and Education, LinkedIn, 1 August 2023.

65 ‘Long-Term Competitiveness of the EU: Looking beyond 2030’, European Commission, 16 March 2023.

66 Silvia Bobba et al., ‘Circular Input Rate: Novel Indicator to Assess Circularity Performances of Materials in a Sector – Application to Rare Earth Elements in e-Vehicles Motors’, Resources, Conservation and Recycling, 1 October 2023.

67 Lisa Depraiter and Stéphane Goutte, ‘The Role and Challenges of Rare Earths in the Energy Transition’, HAL, 2023.

68 Ziwei Li et al., ‘Direct Reuse Strategies of Rare Earth Permanent Magnets for PM Electrical Machines – an Overview Study, The European Physical Journal Applied Physics, 2019.

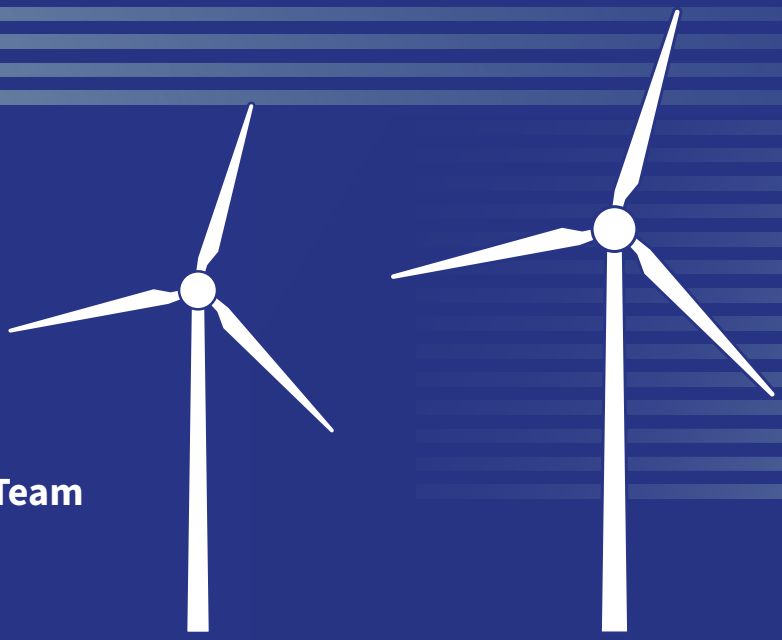
Edition notice

The Analysis and Research Team wishes to recognise the primary contribution of Giovanni Cisco to the drafting of this publication.

Print ISBN 978-92-824-9988-7 doi: 10.2860/3853419 QC-01-24-001-EN-C

PDF ISBN 978-92-824-9987-0 doi: 10.2860/1733979 QC-01-24-001-EN-N

This ART publication was created with the contribution of the Creative Services (DG COMM) of the General Secretariat of the Council.



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