IAI briefs
No. 26|31 (July 2026)

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Strategic Autonomy and Europe's Industrial Vulnerabilities: Clean Technologies and Critical Raw Materials amid Supply Disruptions*

- Accelerating the energy transition will limit fossil fuel dependency, but it will also bring vulnerabilities in the form of clean technologies and critical raw materials, which will complicate the development of the EU strategic autonomy.
- Clean technologies present different profiles in terms of domestic manufacturing, comparative advantages and external dependency. Industrial policy should be rethought to allow for more tailored solutions.
- Structural challenges will continue to hinder the EU's quest for strategic autonomy in clean technology sectors. Industrial stagnation and fragmentated decision-making between member states and European institutions will obstruct the way forward.

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1. Energy security within strategic autonomy

The wave of recent supply shocks – most notably the closure of the Strait of Hormuz, alongside earlier disruptions such as the Covid-19 pandemic, Russia's weaponisation of gas export and increasing global protectionist pressures – has highlighted the fragility of global supply chains. These events have reopened the debate in Europe on energy security and its role within open strategic autonomy. Specifically, the debate is now evolving not just on fossil fuel dependencies, but also on how the energy transition reshapes existing vulnerabilities and how the EU should adjust to rising industrial and clean technology dependencies.

Strategic autonomy – defined as "the capacity of a country or region to pursue strategically important activities free of foreign interference" – is inherently linked with increasing security in the energy sector, in which the EU has historically been exposed to vulnerabilities.[1] Since the 2022 Russia-

* This brief was produced in the framework of the research project "European strategic autonomy and the challenge of new green and digital technologies" supported by the Fondazione CSF and Fondazione Compagnia di San Paolo within the Geopolitics and Technology call. The views expressed in this report are solely those of the author.

1 Kroll, Henning, "Assessing Open Strategic Autonomy", in *JRC External Study Reports*, 2024, https://doi.org/10.2760/767279.

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Ukraine conflict showed the risks of over-dependence and rigid point-to-point import methods, the EU has attempted to increase its energy security moving on different pathways. First, immediate gas-to-gas substitution was made necessary for immediate relief. Second, the EU developed a long-term solution rooted in expanding domestic production and diversifying not just suppliers, but sources as well.

While the first part of this strategy was accomplished mainly through expansion of US and Qatar liquified natural gas (LNG) purchases, the second required a significant ramp-up of renewable energy production. Indeed, the crisis accelerated the development of renewable capacity. Streamlining permitting rules contained in the RepowerEU plan have led to a positive trend in the sector with the share of final energy consumption met by electricity generated from renewable sources in the EU going from 41.2 per cent in 2022 to 47.5 per cent in 2024.[2] However, as gas and oil markets are again spiking and the closure of the Strait of Hormuz highlights limitations of flexible LNG supplies (Qatari LNG has stopped flowing), there is a need for further acceleration of the transition. Energy Commissioner Dan Jørgensen has said that the "EU needs to significantly scale up renewable electricity generation" to deal with instability brought by the conflict in the Middle East.[3] However, while renewable expansion could partially reduce traditional fossil supply dependencies, it also brings new, structurally different vulnerabilities. The resulting issue is that, as the energy transition progresses, the EU will have to deal with vulnerable supply chains of critical raw materials and clean technologies. Indeed, these supply chains in the clean sector have increasingly shown security weaknesses.

» EU needs to significantly scale up renewable electricity generation

2. EU industrial vulnerabilities in the clean energy transition

The most notable example of these security risks is the EU's reliance on Chinese solar panels, the cheap manufacturing costs of which have been instrumental for European decarbonisation but it has also deepened its competitiveness and security vulnerabilities. The EU had been a frontrunner in the sector in the early 2000s, with Germany becoming the main solar panel producer in the global market, but it has since progressively been reduced to marginality.[4] The EU is lagging in scaling up the manufacturing for many other clean technologies. The EU's share of global production of wind components, for instance, has declined from 58 per cent in 2017 to 30 per cent in 2022.[5] The one for lithium-ion batteries stands at barely 8 per cent share of global production.[6] The electrolyser sector appears to satisfy demand for the time

2 Eurostat, *Share of Energy from Renewable Sources*, last updated on 13 May 2026, https://ec.europa.eu/eurostat/databrowser/view/nrg_ind_ren__custom_20344509/default/table.

3 Bonini, Emanuele, "Jørgensen: 'EU Needs to Significantly Scale up Renewable Electricity Generation'", in *Euronews*, 11 March 2026, https://www.eunews.it/en/2026/03/11/jorgensen-eu-needs-to-significantly-scale-up-renewable-electricity-generation.

4 Eddy, Melissa, "Germany's Solar Panel Industry, Once a Leader, Is Getting Squizzed", in *The New York Times*, 25 March 2024, https://www.nytimes.com/2024/03/25/business/germany-solar-panels-china-protectionism.html.

5 Widuto, Agnieszka, "Clean Tech in the Energy Sector", in *EPRS Briefings*, January 2025, https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2025)767198.

6 European Commission DG for Energy, *In Focus: Supercharging the Transition with Energy Storage Solutions*, 16 September 2025, https://energy.ec.europa.eu/node/6801_en.

» The Draghi report points out that technology-specific green industrial policies should be developed

being, with current manufacturing capacity in Europe around 12 gigawatts electrical per year, but it may easily not keep up to the ambitious target of 10 million tonnes of domestic production of renewable hydrogen by 2030 set in the RepowerEU Plan.[7]

Addressing the low industrial capabilities of the EU, as pointed out by the 2024 Draghi Report on the future of EU competitiveness,[8] will require managing trade-offs between decarbonisation, competitiveness and security. The report points out that technology-specific green industrial policies should be developed. For instance, regarding solar panel production – an area, as said, in which Europe has lost its previous advantage – the report suggests maintaining open markets and benefiting from the high manufacturing subsidies offered by producing countries, while diversifying suppliers as much as possible to avoid over-dependence on a single country. By contrast, in sectors like wind turbines, where Europe still holds a strong comparative advantage, public support should be scaled up, both with increased financing and with minimum quotas for locally produced products and components in public procurement. Regarding emerging sectors – such as electrolysers – trade policy tools should be used to shield development, with financing targeted to technologies that show growth potential due to technical innovations.

However, even when innovation is driving up investments and reducing production costs, there are other structural industrial issues which, despite high levels of public support, may prove hard to overcome. The failure of producing a European battery champion was shown by the case of Swedish Northvolt, which filed for bankruptcy in March 2025 despite generous state-aid.[9] Indeed, scaling up Europe's manufacturing capacity for many technologies is limited by such issues as high energy and labour costs. In addition, high green standards drive up production costs and penalise European firms in relation to more polluting competitors. The latter are also cementing their competitive advantage through long-term industrial planning. China, whose companies benefit from vertical integration, lower energy and labour costs, has been developing the 2015 "Made in China" and the 2020 "Dual Circulation" strategy over longer time horizons in which heavy-handed public intervention plays a crucial role. Chinese state subsidies for clean tech manufacturing have been estimated to be around twice as high as those in the EU as a share of GDP.[10]

3. Rising dependencies in unstable supply chains

The increasing gap between the EU and foreign competitors has led to deeper dependencies. China holds dominant production quotas for almost all essential clean technologies: its share in the manufacturing stages of solar

7 Hydrogen Europe, *Electrolyser Manufacturing. Where Does Europe Stand?*, September 2025, https://hydrogeneurope.eu/wp-content/uploads/2025/09/Electrolyser_2025_DIGITAL_1page.pdf; and Widuto, Agnieszka, "Clean Tech in the Energy Sector", cit.

8 Draghi, Mario, *The Future of European Competitiveness. Part A: A Competitiveness Strategy for Europe*, September 2024, https://commission.europa.eu/node/32880_en.

9 Partridge, Joanna, "EV Battery Startup Northvolt Files for Bankruptcy in Sweden", in *The Guardian*, 12 March 2025, https://www.theguardian.com/p/xxmnak.

10 Draghi, Mario, *The Future of European Competitiveness*, cit.

panels (polysilicon, ingots, wafers, cells and modules) exceeds 80 per cent.[11] Chinese quotas for offshore and onshore wind are respectively 70 and 59 per cent; for electrolysers is 41 per cent.[12] Related dependencies concern the critical raw materials (CRMs) crucial for these techs, such as lithium, rare earth elements (REEs), cobalt and nickel.

Precisely because of the rapid expansion of clean technologies (as well as digital and defence ones), demand for CRMs is booming. According to the International Energy Agency, demand for lithium and cobalt is expected to experience a four times increase by 2040, while requests for REE, such as neodymium and dysprosium, may grow up to ten to eleven times by 2050.[13] The Democratic Republic of Congo supplies 70 per cent of cobalt, China provides 60 per cent of REE, Australia accounts for 55 per cent of lithium and Indonesia 40 per cent of nickel. The processing stage is even more concentrated. China alone accounts for the global refining of 90 per cent of REE and almost 70 per cent of lithium and cobalt.[14] Additionally, even for those materials with a wider set of potential suppliers, EU countries remain overly dependent on individual countries, with Turkey, for example, supplying 99 per cent of the boron used in the EU and South Africa 71 per cent of European platinum demand.[15]

» *China has shown a willingness to use export controls and regulatory instruments to influence access to its resources and technologies*

The geopolitical reality of supply chains has made clear how individual trade partners with a dominant position can easily transform dependencies into leverage. China has shown a willingness to use export controls and regulatory instruments to influence access to its resources and technologies. This was first made clear in 2011, when it adopted a REE export ban in retaliation against Japan's seizure of a Chinese ship. More recently, Beijing imposed REE export restrictions in October 2025 to pressure the United States.[16] The new Chinese restrictions require that exporters be issued with licence, and need to provide information on the end users of REEs – information not easily available to the exporter or covered by agreements of non-disclosure with the client. Additionally, the licensing process has been deemed to be arbitrarily selective and slow on purpose to act as non-trade barriers.[17] Even when not directly aimed at the EU, these restrictions have had cascading effects on its economy as well. Firms like Volkswagen, Stellantis, Siemens, Bosch, Solvay and Umicore were strongly impacted, with higher input costs, shortage of materials and fears of interruption of production. Indeed, according to the European Central Bank, many European companies are "no more than three intermediaries away from a Chinese rare earth producer".[18]

11 International Energy Agency, *Special Report on Solar PV Global Supply Chains*, Paris, OECD Publishing, August 2022, https://doi.org/10.1787/9e8b0121-en.

12 Dahlström, Petter et al., "The EU's Comparative Advantage in the 'Clean-Energy Arms Race'", in *The Annals of Regional Science*, Vol. 74, No. 1 (March 2025), Article 14, p. 4, https://doi.org/10.1007/s00168-024-01343-5.

13 Raimondi, Pier Paolo, "EU and Italian De-risking Strategies for Energy Transition: Critical Raw Materials", in *IAI Papers*, No. 25|09 (June 2025), p. 2-3, https://www.iai.it/en/node/20282.

14 Dahlström, Petter et al., "The EU's Comparative Advantage in the 'Clean-Energy Arms Race'", cit., p. 4.

15 Council of the EU website: *Critical Raw Materials Act*, https://www.consilium.europa.eu/en/infographics/critical-raw-materials.

16 Davidson, Helen, "China Steps up Control of Rare-Earth Exports Citing 'National Security' Concerns", in *The Guardian*, 9 October 2025, https://www.theguardian.com/p/x3d837.

17 Gunter, Jacob and Altynay Junusova, "What You Now Need to Know about China's Expansion of REE Export Controls", in *MERICS Interviews*, 15 October 2025, https://merics.org/en/node/2654.

18 Banin, Mattia et al., "How Vulnerable Is the Euro Area to Restrictions on Chinese Rare Earth Exports?", in *ECB Economic Bulletin*, No. 6/2025, p. 40-46 at p. 41, https://www.ecb.europa.eu/press/

4. Industrial responses in the clean tech sector

To address these vulnerabilities and reconcile the EU energy transition with more strategic autonomy considerations, a new set of industrial measures has been adopted or planned. The thematic shift from the Green Deal to the Clean Industrial Deal constitutes a telling sign of this development, despite representing a change of pace, rather than a shift in trajectory.[19]

Results have not matched expectations, however. The 2024 Net-Zero Industry Act (NZIA), the EU's first attempt to support clean technology manufacturing has not sufficiently addressed the security risks of EU's dependency. NZIA aims to satisfy domestically 40 per cent of the demand of technologies considered necessary for reaching climate neutrality, such as wind turbines, solar PV components, electrolysers and batteries by 2030. The list of 19 net-zero technologies has been progressively widened to include carbon capture and storage and biomethane systems, as well as nuclear technologies. This was one of the first limits of the legislation, which instead of focusing primarily on a more restricted set of mature technologies, became a blanket solution for too wide a set.[20] NZIA does recognise projects that add domestic manufacturing capacity in sectors where the EU depends on third countries for over 50 per cent as "net-zero strategic".[21] However, due to its overinclusive list, it does not differentiate between the strategic approaches required by various technologies, as later suggested by the Draghi Report.[22]

» *The planned Industrial Accelerator Act (IAA) is the latest attempt to gather many inputs of the Draghi report*

The planned Industrial Accelerator Act (IAA) is the latest attempt to gather many inputs of the Draghi report. The legislation was published by the Commission in March 2026 but yet to be approved by the Council and Parliament. The IAA introduces mechanisms to increase protection for clean tech sectors. In its current form, strategic and security considerations are among the criteria to evaluate foreign direct investment (FDI) in strategic manufacturing clean tech sectors. This applies to FDI exceeding 100 million euros and carried out by an entity linked with a third country that holds more than 40 per cent of global manufacturing capacity in that specific sector. The IAA overcame the blanket approach of NZIA, as it considers four sectors considered strategic (battery technologies, electric vehicles, solar PV and technologies related to CRMs). It also empowers the designated Investment Authority or the Commission to approve such investments, allowing for EU-wide strategic considerations on a case-by-case basis.[23] This points to the EU realising it is in no position to overcome all technology dependencies and that prioritisation is key. It also aims to boost European companies by leveraging public procurement demand,

economic-bulletin/focus/2025/html/ecb.ebbox202506_01~44d432008e.en.html.

19 Tagliapietra, Simone and Reinhilde Veugelers, "Fostering the Industrial Component of the European Green Deal: Key Principles and Policy Options", in *Intereconomics*, Vol. 56, No. 6 (November 2021), p. 305-310, https://doi.org/10.1007/s10272-021-1006-5.

20 Arroyo, Jane, "What's Net-Zero? Strategic Green Technology Identification in the European Net-Zero Industry Act", in *Politics and Governance*, Vol. 14 (2026), Article 11268, https://doi.org/10.17645/pag.11268.

21 Ragonnaud, Guillaume, "Implementing the EU's Net-Zero Industry Act", in *EPRS Briefings*, February 2025, p. 5, https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2025)769489.

22 Ibid., p. 10.

23 Binder, Johannes et al., "Ambition Without Precision: Why the Industrial Accelerator Act Falls Short", in *Kiel IP-Lab Policy Briefs*, No. 1 (March 2026), p. 19, https://www.kielinstitut.de/publications/ambition-without-precision-why-the-industrial-accelerator-act-falls-short-19599.

introducing more strict local content requirements. These criteria would favour European companies, and they would cover sectors such as electric vehicles, wind turbines, solar and hydrogen technologies. However, member states have already shown to be in disagreements over the exact scope of these local content requirements. Nordic and Baltic states warned that rigid "Made in Europe" criteria would deter investment and distort the internal market, as well as create fractures with long-standing trade partners – proposing instead "Made with Europe" approaches. The final text reflects a compromise, as it defines both "content of Union origin" and "content equivalent to Union origin", the latter of which enjoying the same benefits of the first. This means that commodities from countries with free trade agreements or in a customs union with the EU would be considered equivalent. This approach avoids conflict with trade partners, but it severely reduced the capacity of the IAA to support exclusively European companies.

5. Securing critical raw materials

» Together with clean tech dependencies, developing an open strategic autonomy framework has meant addressing CRM vulnerabilities

Together with clean tech dependencies, developing an open strategic autonomy framework has meant addressing CRM vulnerabilities.[24] The March 2024 Critical Raw Materials Act (CRMA) identifies a set of 34 materials essential for technologies for the green and digital transitions. The CRMA sets ambitious targets by 2030: 10 per cent of the EU's annual requirements of CRMs will need to be extracted domestically, 40 per cent processed within the EU, 25 per cent sourced from recycling: it also sets a ceiling of 65 per cent supply of single CRMs from a single third country.[25] To reach these goals, the CRMA introduces a List of Strategic Projects, designed by the Commission allowing for selected initiatives by European companies related to extraction, processing and recycling to get fast-track authorisation and easier access to funding. The list attempts to build a secure supply chain, attempting to compensate for vulnerabilities at all stages and to create a broad network to diversify suppliers, however the limited resources spent to projects external to the EU is likely to limit the effectiveness of this approach. In December 2025 the EU updates its strategy on CRMs, publishing the RESourcEU Action Plan.[26] The plan builds on the CRMA and aims to facilitate financing, faster permitting and trade with like-minded partners. First and foremost, it represents a significant step-up in terms of funding. The Plan aims to mobilise 3 billion euros to support its goals. It specifically targets batteries and REE to cut dependency on any single foreign supplier by a range between 30 and 50 per cent by 2029.[27] One of the main innovations of the proposed text is the European Critical Raw Materials Centre (CRMC), an initiative to pool demand and coordinate joint purchasing

24 Council of the EU, *Strategic Autonomy: Council Gives Its Final Approval on the Critical Raw Materials Act*, 18 March 2024, https://www.consilium.europa.eu/en/press/press-releases/2024/03/18/strategic-autonomy-council-gives-its-final-approval-on-the-critical-raw-materials-act.

25 European Parliament and Council of the EU, *Regulation (EU) 2024/1252 of 11 April 2024 Establishing a Framework for Ensuring a Secure and Sustainable Supply of Critical Raw Materials*, https://eur-lex.europa.eu/eli/reg/2024/1252/oj/eng.

26 European Commission, *RESourceEU Action Plan* (COM/2025/945), 3 December 2025, https://eur-lex.europa.eu/legal-content/en/TXT/?uri=celex:52025DC0945.

27 Sanderson, Henry, "Europe's New Critical Minerals Plan Will Unlock New Resources, But Permitting and Chinese Involvement Remain Key Hurdles", in *OIES Energy Comments*, December 2025, p. 2, https://www.oxfordenergy.org/?p=49047.

and consequently strengthening companies' collective purchasing power based on how the AggregateEU system worked in the gas sector.[28] However, similarly to the clean tech sector, a more selective stance should be taken regarding CRM as well. Indeed, while basically all CRMs are underdeveloped, some enjoys a larger potential than others and could generate higher strategic value from targeted support. For instance, lithium producers, while still far from being a consolidated presence in Europe, is in an advantageous position due to moderately favourable market conditions and recently found geological reserves on European soil. This was shown by Vulcan's lithium operations in Germany, which was able to secure 250 million euros in financing from the European Investment Bank and 104 million euros by the German government in July.[29] Vulcan's sites in the Upper Rhine Valley are expected to reach an annual output of 24,000 tonnes of lithium hydroxide to be used for battery manufacturing.[30]

6. A bumpy road ahead

» The wave of supply shocks has made the debate over European strategic autonomy dramatically urgent

The wave of supply shocks has made the debate over European strategic autonomy dramatically urgent. As the EU accelerates its energy transition to reduce fossil fuel dependencies, it risks entrenching a new set of vulnerabilities, this time in clean technologies and critical raw materials. The industrial measures introduced in recent years, from NZIA to the IAA and the CRMA, represent a meaningful shift in ambition. Yet, vulnerabilities remain high.

Three structural constraints define the limits of what current EU policy can achieve. The first is fiscal. The EU's financial firepower remains modest compared to its main competitors: unlike the United States or China, the EU only provides for limited, insufficiently targeted and poorly calibrated support to the sectors that need it the most. High energy and labour costs compound the disadvantage, making it structurally difficult for European manufacturers to compete on cost even when public funding is available.

The second constraint is legal. Under Article 173 of the Treaty on the Functioning of the EU, the Commission is limited to "supporting, coordinating or supplementing" member states' industrial policies. This treaty-based ceiling constrains the EU's ability to design and enforce the kind of centralised, long-term industrial strategy that the clean tech challenge demands.

The third, and perhaps most intractable, constraint is political. Divergent national industrial traditions – between interventionist member states such as France and more market-oriented ones such as Germany and the Nordic countries – have slowed down or diluted key legislation. The IAA's protracted negotiations over local content requirements and European preference clauses are a case in point. Fragmentation also runs vertically through the

28 European Commission, *RESourceEU Action Plan*, cit., p. 3.

29 European Investment Bank, *Germany: Vulcan Energy Secures €250 million EIB Financing for Landmark Lithium Project*, 3 December 2025, https://www.eib.org/en/press/all/2025-486-vulcan-energy-secures-eur250-million-eib-financing-for-landmark-lithium-project-in-germany.

30 "Germany Gives Vulcan Energy 104 million Euros to Produce Clean Lithium", in *Reuters*, 22 July 2025, https://www.reuters.com/business/energy/germany-gives-vulcan-energy-104-million-euros-produce-clean-lithium-2025-07-22.

Commission, where persistent tensions between industrial, competition and trade policy directorates-general obstruct coherent action.

Together, these constraints leave the EU in a paradoxical position: politically committed to an energy transition that reduces one form of dependency, yet structurally ill-equipped to prevent that transition from generating another. Breaking this pattern would require a reconfiguration of governance – greater fiscal pooling and even treaty reform – which could enable the development on an industrial policy to avoid replicating, in the clean energy sector, the same vulnerabilities it is today trying to leave behind in fossil fuels. On the fiscal side, the developing of common financing tools for supporting clean technologies would avoid possible distortion to the single markets that just increasing state-aid flexibility could lead to. A more selective industrial policy would allow for channelling funding where needed – and where more effective in the long term. An integrated approach of energy and industrial policy should also be developed, securing solutions to lower energy prices for energy intensive industries and securing supplies of reliable energy carriers.

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Interim Editor: **Riccardo Alcaro** (r.alcaro@iai.it)
ISSN 3103-4071 | DOI 10.82088/IAIbrief2631