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Italy's De-Risking Efforts in the Semiconductor Industry, the European Chips Act and Sino-American Geo-Economic Competition

by Aurelio Insisa

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ABSTRACT

As a strategic narrative, de-risking encapsulates aspiration to diversify supply chains and enhance domestic economic resilience. Like other European countries, Italy has also made efforts to "de-risk" its semiconductor industry. It has crafted targeted industrial policies addressing real vulnerabilities despite limited fiscal capacity, following a clear-eyed approach to its position in global semiconductor supply chains, with strategic investments in mature chips and advanced packaging that mitigate emerging dependencies on Chinese manufacturing. However, challenges persist: the European Chips Act's ambitious target to double the EU's global market share appears unrealistic, and the unpredictable trajectory of Sino-American competition threatens to undermine European self-reliance efforts in this critical sector.

Italy | Semiconductor industry | Supply chains | China | Transatlantic relations

keywords

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Introduction

Four years removed from the chip shortage that affected global manufacturing in the wake of the Covid-19 pandemic, chip-making has remained at the centre of global geo-economic dynamics.[1] The 2021 “chip crunch” exposed a major vulnerability of the semiconductor industry: the extreme concentration of its supply chains in East Asia, in particular on the island of Taiwan, in the most advanced segments of production. The impact of the first major outbreak of the Covid-19 virus in Taiwan after the early containment of the disease, together with extended droughts affecting the provision of water necessary for the local plants, dramatically affected the capacity of local chipmakers to meet global demand.[2]

This crisis acted as a catalyst, in turn, for pre-existing trends pushing for the reshoring of the semiconductor industry among developed economies following the delocalisation to East Asia between the 1990s and 2000s. On the one hand, the chip crunch fed into pre-existing concerns about the economic and socio-political impacts of de-industrialisation in Western countries.[3] On the other hand,

[1] Geo-economics can be described as “[t]he use of economic instruments to promote and defend national interests, and to produce beneficial geopolitical results; and the effects of other nations’ economic actions on a country’s geopolitical goals”. See Robert D. Blackwill and Jennifer M. Harris, *War by Other Means. Geoeconomics and Statecraft*, Cambridge/London, The Belknap Press of Harvard University Press, 2016, p. 20.

[2] Aurelio Insisa, “Taiwan 2021: Heightened Geo-Economic Relevance amid Rising Cross-Strait Tensions”, in *Asia Maior*, Vol. 32/2021 (2022), p. 139-141, https://www.asiamaior.org/?p=1432.

[3] Nurullah Gur and Serif Dilek, “US-China Economic Rivalry and the Reshoring of Global Supply Chains”, in *The Chinese Journal of International Politics*, Vol. 16, No. 1 (Spring 2023), p. 61-83, DOI

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it highlighted growing concerns over the continuing viability of Taiwan as the dominant hub for global advanced chip-making, due to increasing tensions in relations between Taipei and Beijing after the return to power of the Democratic Progressive Party on the island in 2016,[4] and the parallel strengthening of US relations with Taiwan in the context of Washington's own bilateral relations with China under the first Trump administration and the Biden presidency.

Western aspirations for remaking the chip industry in the wake of the Covid-19 pandemic have gone beyond concerns about supply chain concentration in Taiwan. Securitising the semiconductor industry has also meant to address existing dependencies on Beijing in sourcing the critical materials necessary for chip-making, given Chinese dominance in this specific supply chain.[5] At a deeper level, Western – and specifically American – aspirations to remake the chip industry have been inextricably tied to stifling China's own plans for "semiconductor independence" in the production of the most advanced chips, which traces back to the mid-2010s.[6] Washington's ever-expansive use of export controls targeting the semiconductor industry between 2022 and 2025,[7] coupled with the promulgation of a 280 billion US dollars CHIPS and Science Act in 2022 also aimed at revitalising chip-making in the United States, has aimed at preventing future economic, technological and security dependencies on Beijing. The goal is to avoid outcomes similar to those already emerging in the field of green technologies (with Chinese companies dominating solar panels and electric vehicle production), while imposing these very same dependencies on partners and competitors alike. After all, chips are not only essential for the production of sophisticated electronic systems, including weapon systems, but also play a fundamental role in the development of artificial intelligence (AI).

Within this context, by 2023 both the European Union and the United States espoused a strategic narrative of "de-risking".[8] The aim was to communicate a shared approach towards economic dependencies towards China that dispensed

10.1093/cjip/poac022.

[4] Aurelio Insisa, "No Consensus across the Strait: Chinese and Taiwanese Strategic Communications in a Contested Regional Order", in *Asian Perspective*, Vol. 45, No. 3 (Summer 2021), p. 503-531, DOI 10.1353/apr.2021.0033.

[5] Roland Howanietz, *China's Virtual Monopoly of Rare Earth Elements. Economic, Technological and Strategic Implications*, London/New York, Routledge, 2018; June Nakano, "The Geopolitics of Critical Minerals Supply Chains", in *CSIS Reports*, March 2021, https://www.csis.org/node/60182; Philip Andrews-Speed and Anders Hove, "China's Rare Earths Dominance and Policy Responses", in *OIES Papers*, No. CE7 (June 2023), https://www.oxfordenergy.org/?p=46247.

[6] James A. Lewis, "Learning the Superior Techniques of the Barbarians. China's Pursuit of Semiconductor Independence", in *CSIS Reports*, January 2019, https://www.csis.org/node/50245.

[7] Reva Goujon and Ben Reynolds, "Slaying Self-Reliance: US Chips Controls in Biden's Final Stretch", in *Rhodium Group Notes*, 9 December 2024, https://rhg.com/?p=9793; Bharath Harithas, "The AI Diffusion Framework: Securing U.S. AI Leadership while Preempting Strategic Drift", in *CSIS Reports*, February 2025, https://www.csis.org/node/114733.

[8] Strategic narratives are narratives designed to structure responses facilitating the achievement of strategic objectives. See Alister Miskimmon, Ben O'Loughlin and Laure Roselle, *Strategic Narratives. Communication Power and the New World Order*, London/New York, Routledge, 2013.

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of earlier, unrealistic expectations of "de-coupling" from the world's second largest economy and premiere manufacturing hub. De-risking was framed as a new modus operandi primarily focusing on strategic diversifying trade partners beyond China and enhancing economic resilience at home to pre-emptively avoid external shocks from Beijing.[9] Yet, US actions to remake the chip industry vis-à-vis China highlight the distinct plight of the EU and its member states. The stakes, in fact, have been fundamentally different. For the United States, de-risking has ultimately meant maintaining its technological, economic and military edge over China through the control of arguably the most critical industrial sector of the early 21st century.[10] For the EU and its member states, de-risking has meant an attempt to reduce technological dependencies and the revitalisation of a shrinking industrial base in advanced manufacturing within a geo-economic context primarily shaped by Washington and Beijing, relying on smaller diplomatic, legal and fiscal tools than the two global powers. The European Chips Act, effective since September 2023, is a case in point. The objective is ambitious: to double the EU share of global production capacity, in terms of value, from 10 to 20 per cent. Yet the comparison with its US equivalent is unfavourable. The CHIPS and Science Act has committed 278.2 billion US dollars between direct subsidies and tax incentives,[11] including a crucial allocation of up to 39 billion US dollars, dubbed the "CHIPS for America Fund" and including direct loans and loan guarantees, aiming at accelerating domestic chip production.[12] The European Chips Act, instead, creates a 43 billion euros fiscal space within the EU common market comprising direct EU subsidies and possible private investments and state aid according to precise parameters.[13]

Against this backdrop, this paper zooms in on the pursuit of de-risking in the chip industry by one EU member state that plays a secondary, yet nonetheless meaningful role in the continent's production of these goods: Italy. By doing so,

[9] The President of the EU Commission Ursula von der Leyen officially introduced the concept of de-risking in March 2023. White House National Security Advisor Jake Sullivan "adopted" this narrative in another speech the following month. See European Commission, *Speech by President von der Leyen on EU-China Relations to the Mercator Institute for China Studies and the European Policy Centre*, 30 March 2023, https://ec.europa.eu/commission/presscorner/detail/en/speech_23_2063; White House, *Remarks by National Security Advisor Jake Sullivan on Renewing American Economic Leadership at the Brookings Institution*, 27 April 2023, https://bidenwhitehouse.archives.gov/briefing-room/speeches-remarks/2023/04/27/remarks-by-national-security-advisor-jake-sullivan-on-renewing-american-economic-leadership-at-the-brookings-institution.

[10] Agathe Demarais, "What Does 'De-Risking' Actually Mean?", in *Foreign Policy*, 23 August 2023, https://foreignpolicy.com/?p=1121921; Brad Glosserman, "De-Risking Is Not Enough: Tech Denial toward China Is Needed", in *The Washington Quarterly*, Vol. 46, No. 4 (2023), p. 103-119, DOI 10.1080/0163660X.2023.2286134.

[11] Justin Badlam et al., "The CHIPS and Science Act: Here's What's in It", in *McKinsey Articles*, 4 October 2022, https://www.mckinsey.com/~/media/mckinsey/industries/public%20and%20social%20sector/our%20insights/the%20chips%20and%20science%20act%20heres%20whats%20in%20it/the-chips-and-science-act-heres-whats-in-it.pdf.

[12] Mackenzie Hawkins, "With US Chips Act Money Mostly Divvied Up, the Real Test Begins", in *Bloomberg*, 9 August 2024.

[13] Nicola Bilotta, "Chips: EU'S Ambition in a Transatlantic Technology Bridge", in *IAI Papers*, No. 24|06 (February 2024), p. 6-7, https://www.iai.it/en/node/18150.

this paper provides a granular view of how state actors have been adapting to major geo-economic drivers across multiple geopolitical and fiscal constraints, devising a new industrial policy to reshore chip-making in a developed economy that had previously experienced delocalisation.

1. Semiconductors and their supply chains

Semiconductors, commonly known as "microchips" or "chips", are devices made by integrating billions of transistors onto a silicon substrate – a material with semiconducting properties. These transistors form complex integrated circuits that perform a variety of electronic functions. Chips operate based on the binary principle, processing information through transistors that switch between discrete electrical states – typically representing the logical values 0 and 1. This switching enables chips to perform calculations, execute instructions, process signals, make logical decisions and store data. According to their function, they are classified as "memory chips" (for data storage), "logic chips" (for data processing) and "DAO (discrete, analogue and other) chips" for executing a wide range of specific functions. A second way to categorise chips is by their "node size", which refers to the manufacturing process used to produce transistors on a chip. The node size, measured in nanometres (nm), indicates the scale of the features etched onto the silicon wafer, particularly the length of the transistor gate. Smaller node sizes generally allow more transistors to be packed into a given area, improving performance and energy efficiency. The terminology of the US CHIPS and Science Act dubs chips below the 28 nm threshold as "advanced". Chips above this threshold are defined as "mature nodes", even though a more common term especially among media and commentators is "legacy chips".[14]

The supply chain of chips is divided into three macro-segments: design, front-end production and back-end production.[15] The *design* segment of the semiconductor industry can be divided into two further segments. The first is the development of design tools and reusable components, commonly known as "electronic design automation" (EDA) and "IP (intellectual property) development". This segment provides the software tools and pre-designed functional blocks necessary to design chips. The second segment is "chip design" itself, where companies use these tools and IP cores to create specific chips tailored to the requirements of electronic devices and systems. Chip design is also known as "fabless design", because the companies involved do not own the "fabs" (also called "foundries") where the chips they design are manufactured.[16] *Front-end production* refers to the initial and most

[14] US Congress, *H.R.4346 - CHIPS and Science Act*, 9 August 2022, https://www.congress.gov/bill/117th-congress/house-bill/4346/text.

[15] Sophie-Charlotte Fischer, "Silicon Curtain: America's Quest for Allied Export Controls against China", in Brian G. Carlson and Oliver Thränert (eds), *Strategic Trends 2023. Key Developments in Global Affairs*, Zurich, ETH Zürich, 2023, p. 39-61 at p. 50, https://doi.org/10.3929/ethz-b-000614506.

[16] Ibid., p. 51.

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critical phase of chip manufacturing, during which transistors and other circuit elements are formed on the surface of silicon wafers. This stage includes multiple processes: wafer fabrication, oxidation, photolithography, etching, deposition and metallisation.[17] The final macro-segment of the supply chain is *back-end production*, also referred to by the acronym ATP, which stands for "assembly, testing and packaging". While often summarised under this acronym, back-end production encompasses several distinct processes: backgrinding, wafer dicing, die attach, interconnection, moulding, marking, solder ball mounting, singulation, encasing (also known as packaging) and testing.[18]

The supply chain segmentation described above pertains primarily to a process defined as "*monolithic chip design*", in which all components of a chip are fabricated as a single, integrated unit on one silicon die. An emerging alternative is *chiplet-based design* – a modular architecture in which individual functional blocks, or "chiplets", are first designed, manufactured and tested separately, and then integrated into a single package. This approach allows for greater flexibility, scalability and potential cost savings by enabling the reuse and customisation of chiplets across different products. Chiplets are produced through standard semiconductor fabrication processes, but their integration into a functional system relies on "advanced packaging" technologies.[19]

The leading companies in IP development are American – Cadence, Synopsis, Mentor, except for the British company ARM. The champions in chip design (also known as "fabless design") are also American (Apple, Broadcom, Nvidia, Qualcomm) as well as Taiwanese (Himax, MediaTek and Realtek) and British (Dialog).[20] Front-end production, as discussed in the introduction, is extremely concentrated in East Asia, especially for the most advanced nodes of production. Current global foundry market shares show the dominance of the Taiwanese public company TSMC (Taiwan Semiconductor Manufacturing Company), with the South Korean Samsung Foundry only a distant competitor, followed further down the line by

[17] SK Hynix Newsroom website: *Front-End Processes*, in https://news.skhynix.com/tag/front-end-process. For an alternative taxonomy of front-end processes, see Alison Li, "6 Crucial Steps in Semiconductor Manufacturing", in *ASML Stories*, 4 October 2023, https://www.asml.com/en/news/stories/2021/semiconductor-manufacturing-process-steps.

[18] "Semiconductor Back-End Process Episode 6: The Eight Steps of Assembling Conventional Packages", in *SK Hynix Newsroom*, 3 August 2023, https://news.skhynix.com/?p=12187; "Semiconductor Back-End Process Episode 11: Reliability Tests and Standards for Semiconductor Packages", in *SK Hynix Newsroom*, 20 December 2023, https://news.skhynix.com/?p=13672.

[19] Chiplets are produced through standard semiconductor fabrication processes, but their integration into a functional system relies on advanced packaging technologies. These include techniques such as 2.5D and 3D integration, silicon interposers and high-density interconnects, which allow multiple chiplets to communicate efficiently within a single package. See Semiconductor Engineering website: *Advanced Packaging*, https://semiengineering.com/knowledge_centers/packaging/advanced-packaging.

[20] Sophie-Charlotte Fischer, "Silicon Curtain", cit., p. 53; Henry Wai-chung Yeung, *Interconnected Worlds. Global Electronics and Production Networks in East Asia*, Stanford, Stanford University Press, 2022, p. 43.

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the Chinese SMIC, the Taiwanese UMC and the American GlobalFoundries.[21] The major global players in the back-end production are the Taiwanese ASE, PTI and KYEC, the American Amkor and the Chinese JCET, TFME and Huatian.[22]

Any overview of the articulation of the supply chains of chips, however, must also consider the role of the companies involved in the provision of materials chemicals and machinery necessary for front-end and back-end production. The provision of materials and chemicals for mature chips is dominated by Chinese companies.[23] When it comes to advanced chips, the major players for materials and chemicals are the Japanese companies Shin Etsu Chemical, Sumco and Tokuyama, the Taiwanese company Global Wafers, and three European companies: Siltronic (Germany), Soltec (Spain) and Okmetic (Finland).[24] The key company in the machinery sector for advanced chips is the Netherlands' ASML, which holds a monopoly in the production of extreme ultraviolet photolithographic (EUV) machines. Other important companies in this sector are the American Applied Materials and Lam Research and the German Carl Zeiss SMT, which produce components for ASML's EUV machinery. ASML is also the leading producer for DUV (deep ultraviolet) photolithographic machines, which are used for the front-end production of less advanced ranges of chips, followed by the Japanese companies Nikon and Canon. Another Japanese company, Tokyo Electron, plays instead a crucial role in the supply of coater/developer systems for both EUV and DUV machinery.[25]

Front-end production has been at the segment at the centre of the geo-economic developments reshaping the semiconductor industry since the pandemic-era "chip crunch", because the major technological chokepoints in the production of advanced chips are present in this segment. An overview of the fundamental steps in the supply chain of the most advanced chip for AI training, the 4-nm Blackwell Ultra BG300 produced by the US company NVIDIA, neatly provides a window into this situation. These logic chips are mass-produced in the TSMC fabs in Taiwan utilising ASML's EUV photolithography machinery.

As a result, TSMC and ASML are often described as the two single most crucial players in the global semiconductor industry. Yet, ASML's production of EUV machinery relies, as mentioned above, on mirrors and lenses produced by Carl Zeiss SMT, which in turn relies on subsystems and IP provided by US companies such as Keysight Technologies, and on high-powered lasers produced by another US-based company, Cymer, an ASML subsidiary since 2023 whose IPs are still subject to the US government's jurisdictional control.[26]

21 Sophie-Charlotte Fischer, "Silicon Curtain", cit., p. 53.
22 Ibid.
23 Ibid.
24 Ibid.
25 Ibid.
26 Marc Hijink, Focus: *The ASML Way. Inside the Power Struggle over the Most Complex Machine on Earth*, Amsterdam, Balans, 2024, ch. 26, 30.

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The "fabless" model of production, exemplified above through the case of NVIDIA advanced chips, which revolves around the separation between companies tasked with chip designs and front-end companies operating the foundries, first emerged in the late 1980s, but it became dominant in the manufacturing of advanced chips only since the late 2000s.[27] Yet, other companies have continued to operate as "integrated device manufacturers" or IDMs. These companies own and operate the "fabs" necessary for the front-end production of the chips that they design, as well as the plants for back-end production. Major IDM players in the industry are the American companies Intel and Texas Instruments, the Japanese Kioxia and Renesas, the South Korean Samsung and SK Hynix, the German Infineon, the Dutch NXP and the Franco-Italian STMicroelectronics.[28]

2. Italy's semiconductor industry

Italy is a marginal player in a global semiconductor industry that totalled 626 billion US dollars in revenues in 2024.[29] It is nonetheless a relevant player at the European level, especially in the production of chips for the automotive, industrial and aerospace sectors. The sector is indeed expected to reach 2.3 billion US dollars in revenues in 2025.[30] The major player at a national level is STMicroelectronics, with a net revenue of 13.2 billion US dollars in the 2024 fiscal year and a market capitalisation of 22.5 billion US dollars by the year's end.[31] Twenty-eight per cent of the company is owned by STMicroelectronics Holding NV – a holding company registered in the Netherlands and controlled on equal shares by Bpifrance and Italy's Ministry of Economics and Finance. The remaining 72 per cent is owned by non-state shareholders.[32]

STMicroelectronics mainly operates as an IDM, with facilities in France, Italy, Malta, Sweden, Morocco, China, the Philippines, Malaysia and Singapore, even though it still relies on external foundries for the manufacturing of certain products. Its operations in Italy include a research centre in Catania (Sicily), two front-end facilities in Agrate Brianza (Lombardy) and Catania, as well as a minor back-end

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[27] Chris Miller, *Chip War. The Fight for the World's Most Critical Technology*, New York, Simon and Schuster, 2022, ch. 30-31.

[28] Sophie-Charlotte Fischer, "Silicon Curtain", cit., p. 53.

[29] Gartner, *Gartner Says Worldwide Semiconductor Revenue Grew 18% in 2024*, 3 February 2025, https://www.gartner.com/en/newsroom/press-releases/2025-02-03-gartner-says-worldwide-semiconductor-revenue-grew-18-percent-in-2024.

[30] Statista: *Semiconductors – Italy*, https://www.statista.com/outlook/tmo/semiconductors/italy.

[31] STMicroelectronics, *STMicroelectronics Q4 & FY 2024 Financial Results*, 30 January 2025, https://investors.st.com/static-files/e849a285-a85f-4d04-9212-5b0c8e0afbd8; Macrotrends website: *STMicroelectronics Market Cap 2010-2024 | STM*, https://www.macrotrends.net/stocks/charts/STM/stmicroelectronics/market-cap.

[32] STMicroelectronics website: *Governance*, https://sustainabilityreports.st.com/sr22/company/governance.html.

facility in Marcianise (Campania).[33]

STMicroelectronics owns a wide portfolio of technologies for DAO chips, such as microcontroller units for the automotive sector, including for key electronic vehicle (EV) producers such as Tesla and BYD; discrete and power transistors; proximity and ranging sensors; analogue, industrial and power conversion integrated circuits; and chips for 5G communication technologies.[34] In detail, the Agrate site includes a fabrication facility for 200 mm (8-inch) wafers, as well as a new 300 mm (12-inch) wafer fab that began production in 2023.[35] The Catania site is one of the largest centres in the world for the development of power and smart power semiconductors and it will soon expand with the establishment of an innovative hub for the integrated manufacturing of chips in silicon carbide (SiC) rather than traditional silicon.[36]

Another important player at a national level, even though at the front-end production segment, is the Abruzzo-based company LFoundry. Between 2016 and 2019, the majority shareholder of LFoundry was the Chinese state-owned company SMIC, a major player in the global foundry market and a key player in the Chinese semiconductor ecosystem together with Huawei.[37] Since 2019, the major shareholder has been another Chinese company, Wuxi Xichanweixi. LFoundry specialises in 200mm wafer production and offers mature process nodes, including 150nm and 110nm, with the fabless US company Onsemi, specialised in DAO chips, being its main client.[38] Another relevant player in Italy is MEMC. The company is based in Piedmont and is wholly owned by Global Wafers. It operates two plants to produce components for wafers in Merano and Novara. The Merano plant produces crystals for 150 mm advanced wafers that are subsequently assembled in East Asia, while the Novara plant produces "slices" for 200mm wafers.[39] Finally, within the back-end production segment, two Turin-based companies stand out: Spea

[33] Arsenio Spadoni, "L'Italia dei chip, una panoramica dell'industria italiana dei semiconduttori", in *Elettronica & Mercati*, 28 March 2024, https://www.elettronicaemercati.it/?p=19793.

[34] STMicroelectronics website: *Product Portfolio*, https://www.st.com/content/st_com/en/browse/product-portfolio.html.

[35] STMicroelectronics website: *Agrate, Italy*, https://www.st.com/content/st_com/en/about/manufacturing-at-st/our-facilities/agrate-st-site.html.

[36] STMicroelectronics website: *Catania, Italy*, https://www.st.com/content/st_com/en/about/manufacturing-at-st/our-facilities/catania-st-site.html. "Silicon carbide (SiC) is a compound semiconductor material that offers superior performance compared to traditional silicon. Chips made from this material can operate at higher temperatures, higher voltages, and higher frequencies, making them ideal for applications that require high power and efficiency". See Bosch website: *Advantages of Silicon Carbide Chips: the Future of Electric Vehicles*, https://www.bosch-semiconductors.com/stories/advantages-of-silicon-carbide-chips-the-future-of-electric-vehicles.

[37] Antonia Hmaidi, "Huawei Is Quietly Dominating China's Semiconductor Supply Chain", in *MERICS Briefs*, April 2024, https://merics.org/en/node/2175.

[38] Arsenio Spadoni, "Il paradosso LFoundry, il produttore italiano di semiconduttori di proprietà cinese", in *Elettronica & Mercati*, 25 September 2021, https://www.elettronicaemercati.it/?p=3798.

[39] Arsenio Spadoni, "MEMC, un'altra eccellenza italiana della microelettronica, produrrà wafer da 300 mm nel nuovo impianto di Novara", in *Elettronica & Mercati*, 20 February 2020, https://www.elettronicaemercati.it/?p=7434.

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and Technoprobe. Spea is a company focusing on testing processes for chips.[40] Technoprobe is a global player in the production of probe cards, the tools tasked with connecting chips to testers, and an important supplier to STMicroelectronics.[41]

Italy houses other relevant companies in the semiconductor industry. One is the Milan-based LPE, which produces epitaxial reactors, which are machinery used for the deposition process in semiconductors. In 2021, the Italian government exercised its special powers over the corporate structures of companies operating in sectors relevant to national security (colloquially known as "golden power") to stop the acquisition of a controlling stake in LPE by the Chinese state-owned capital investment platform Shenzhen Investment Holdings.[42] Following this decision, LPE was eventually acquired by a Dutch company, specialised in wafer processing, ASM.[43] Like STMicroelectronics, LPE also owns a research centre in Catania, together with another centre in Shanghai for installation, sales and service of its products.[44]

Another player worth mentioning in this context is Meridionale Impianti (MI), a company based in Lombardy specialising in the production of "white rooms" – artificial environments for front-end production created to maintain extremely low levels of airborne particles, contaminants and pollutants that would otherwise affect manufacturing processes. MI is also a key producer of laminar flow systems designed to ensure cleanliness and absence of contamination in the white rooms.[45] Like MI, another important supplier to STMicroelectronics also based in Lombardy is Sapio, which produces and distributes gases used in the various phases of chip production, from wafer manufacturing to metal wiring.[46]

This overview of the major players operating in Italy shows glaring deficiencies and relevant strengths in the country's semiconductor industry. There is no player operating either as IDM or as a designer or as front-end producer for the most advanced nodes below 28 nm. The national industry landscape is dominated by STMicroelectronics, an IDM focusing on the production of DAO chips, while the only player operating as a fab (namely, in the guise of a company such as TSMC) is LFoundry, which is owned by a Chinese company. There is, however, a wide

[40] SPEA website: *Semiconductor Test*, https://www.spea.com/?p=1965.

[41] Technoprobe website: *Our Technologies*, https://www.technoprobe.com/technologies-and-products/our-technologies.

[42] Italian Government Department for European Affairs, *Golden Power* (in Italian), 20 June 2023, https://www.affarieuropei.gov.it/it/comunicazione/europarole/golden-power. See also: Beatrice Gallelli and Lorenzo Mariani, "China in Italy: Risk Assessment and Preventive Solutions", in *IAI Papers*, No. 21|52 (December 2021), https://www.iai.it/en/node/14476.

[43] ASM, *ASM Completes Acquisition of LPE*, 3 October 2022, https://www.asm.com/press-releases/asm-completes-acquisition-of-lpe-2527162.

[44] Alberto Brambilla and Daniele Lepido, "China Targeted Milan Semiconductor Firm before Draghi's Veto", in *Bloomberg*, 9 April 2021, https://www.bloomberg.com/news/articles/2021-04-09/china-targeted-milan-semiconductor-firm-before-draghi-s-veto.

[45] Meridionale Impianti website: *Hi-Tech Industrial* (in Italian), https://www.merimp.com/?p=8756.

[46] Sapio website: *Catalogo gas*, https://www.sapio.it/miscele.

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range of relevant players at the European level focusing on the production of components for both front-end and back-end production (MEMC, Spea, LPE) and on chip manufacturing facilities (MI and Sapio), with Technoprobe being a major player at a global level in a niche of back-end production.

3. The evolving logic of de-risking in Italy's semiconductor industry

How has Italy pursued "de-risking" in the semiconductor industry since the 2021 chip crunch and the successive launch of the EU's European Chips Act? The earlier steps made by the government led by Mario Draghi in 2022 involved discreet talks with representatives of the Taiwanese government for a potential TSMC investment in Italy.[47] These talks suggested Italy's interest in reshoring the front-end production of advanced chips. However, the prospect of a TSMC foundry in the country rapidly petered out. In August 2023, TSMC announced that it would instead lead a new joint venture together with German companies Bosch and Infineon and Dutch company NXP. The joint venture, called ESMC (European Semiconductors Manufacturing) would establish a new foundry in the German city of Dresden with an overall investment of 10 billion US dollars. ESMC plans to manufacture chips ranging between the 28 and the 12 nm nodes by 2027, with a focus on the automotive sector.[48] Germany's advantage over Italy lay in the country's leadership in European manufacturing (especially in the automotive sector), involvement of major players in the European semiconductor industry, as well as in the German government's fiscal capacity, which guaranteed a 5 billion US dollar contribution to the overall investment.[49]

A separate negotiation with the US company Intel, this time for the establishment of a back-end production hub for advanced packaging,[50] which were initially conducted by the Draghi government between 2021 and 2022, also failed to reach results by 2023.[51] The Draghi government had originally allocated 4.1 billion euros to convince Intel to invest in the country.[52] Coming to power in October 2022, the Meloni government refashioned these funds into a 3.3 billion euro National Microelectronics Fund, which it integrated with 450 million euros available under

[47] Federico Fubini, "Chip, il colosso di Taiwan Tsmc vuole sbarcare in Italia (e investire 10 miliardi)", in *Corriere della Sera*, 16 May 2022.

[48] TSMC, *ESMC Breaks Ground on Dresden Fab*, 20 August 2024, https://pr.tsmc.com/english/news/3169.

[49] Ibid.

[50] On advanced packaging, see note 19.

[51] Filippo Santelli, "Intel archivia l'investimento in Italia: 'Nessun piano attivo, concentrati su Germania e Polonia'", in *La Repubblica*, 16 January 2024.

[52] The fund was created by a law decree adopted in March 2023. The law decree is a decree (that is, an act by the executive) that has the force of law (that is, an act of the legislative) but must be converted into law within sixty days from its promulgation. It is a special power the government can resort to only in emergencies but has been used more frequently as a way to speed up the legislative process.

the National Recovery and Resilience Plan.[53] It is also worth noticing that the so-called "Assets Decree" of October 2023, which provided the legal backdrop of the National Microelectronic Fund, also established a Permanent Technical Committee for Microelectronics within the Ministry of Enterprises and Made in Italy (MIMIT), including representatives from the Ministry of Economy and Finance and the Ministry of University and Research.[54]

The flagship project emerging from this new industrial policy was STMicroelectronics' plan for the first fully integrated facility to produce silicon carbide chips in Catania, announced in May 2024. This new plant will produce chips for power devices and modules critical to the automotive, industrial and cloud infrastructure applications, to be built on 200 mm SiC wafers.[55] The project, worth 5 billion euros, is supported by a public investment of approximately 2 billion euros that occurred within the framework of the European Chips Act. This is the second largest project ever approved by the European Commission within this regulatory package after ESMC Dresden.[56]

A second flagship project is a 3.2 billion euros investment by the Singaporean company Silicon Box. Announced in March 2024, supported by a 1.3 billion euros contribution by the Italian state, and approved by EU authorities in December 2024, this investment will lead to the establishment of a new plant in Novara (Piedmont) for advanced packaging for the manufacturing of chiplets to be used for AI supporting large language models (LLM), for high performance computing (HPC) and for EVs – amongst others.[57]

Other investments spearheaded by the National Fund include the expansion of the MEMC plant already present in Novara to produce 300 mm silicon wafers in 2023, which enjoyed 103 million euros in state aid within the framework of the EU's IPCEI ME/CT (Important Projects of Common European Interest on microelectronics

[53] Arsenio Spadoni, "Aumenta nel 2023 il ritardo dell'industria italiana dei semiconduttori dal resto dell'Europa e del mondo", in *Elettronica & Mercati*, 8 January 2024, https://www.elettronicaemercati.it/?p=18984. The National Microelectronics Fund was established by an Italian Government Decree of 27 October 2023, promulgated against the backdrop of the previous "Urgent provisions for the protection of users, in the field of economic and financial activities and strategic investments" of the Decree-Law of 10 August 2023, No. 104, Art 5 – the so-called "Assets Decree". See Italian Goverment, *Definizione degli ambiti di applicazione e di intervento, dei criteri e delle modalità di riparto delle risorse del Fondo finalizzato a promuovere la ricerca e lo sviluppo della tecnologia dei microprocessori e l'investimento in nuove applicazioni industriali di tecnologie innovative*, 27 October 2023, https://www.gazzettaufficiale.it/eli/id/2023/12/04/23A06630/sg.

[54] Ibid.

[55] On the advantages of SiC chips over traditional silicon chips, see note 36.

[56] STMicroelectronics, *STMicroelectronics to Build the World's First Fully Integrated Silicon Carbide Facility in Italy*, 31 May 2024, https://newsroom.st.com/media-center/press-item.html/c3262.html.

[57] Italian Ministry of Enterprises and Made in Italy (MIMIT), *Urso annuncia un maxi investimento da 3,2 miliardi di Silicon Box in Italia*, 11 March 2024, https://www.mimit.gov.it/it/notizie-stampa/urso-annuncia-un-maxi-investimento-da-3-2-miliardi-di-silicon-box-in-italia; Silicon Box, *Silicon Box Selects Piedmont to Host €3.2B Chip Foundry for Italian Expansion*, 28 June 2024, https://www.silicon-box.com/silicon-box-selects-piedmont-to-host-3-2b-chip-foundry-for-italian-expansion.

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and communication technologies).[58]

Finally, state funds worth 225 million euros were provided to support the establishment of the Chips-IT Foundation (also known as the Italian Centre for the Design of Integrated Circuits for Semiconductors), launched in November 2023 in Pavia, which aims at fostering advanced research on chip design through cooperation with foreign and national companies in the sector.[59]

Have these investments contributed to the EU's broader efforts to "de-risk" the semiconductor industry from exogenous shocks such as the 2021 chip crunch and the threat of new technological dependencies from China?

Notwithstanding the multiple initiatives mentioned above, the Italian contribution ultimately revolves around the two flagship projects launched by STMicroelectronics and Silicon Box. Both projects meet the requirements of the second pillar of the European Chips Act, namely the funding of "first of its kind" facilities to "ensure the security of supply and resilience of the Union's semiconductor sector by attracting investments and enhancing production capacities in manufacturing, advanced packaging, test, and assembly".[60] However, it remains difficult to assess their weight in the context of the Act's ambition to double the EU's share in the global market value chain by revenue from 10 per cent (as in 2023) to 20 per cent by the year 2030. In fact, an April 2025 report by the European Court of Auditors on the state of the Act even stated that "given the current level of investment in manufacturing capacity, the [European Chips Act] strategy is very unlikely to be sufficient to achieve by 2030 the [...] target of a 20% EU share", predicting instead a mere 11.7 per cent by that year.[61] Perceptive analyses of the European Chips Act have indeed criticised the focus on such targets highlighting how the Act itself risks enabling "a collection of initiatives and efforts that cut across the semiconductor value chain rather than a long-term strategy rooted in current geopolitical realities".[62] A way forward to avoid this outcome and achieve *real* de-risking, as it has been argued, is for EU member states to "enhance and intensify their efforts to understand their

[58] "EC and Italian Government Awards IPCEI ME/CT Funding to GlobalWafers/MEMC to Establish 300mm Wafer Production", in *Semiconductor Today*, 26 June 2024, https://www.semiconductor-today.com/news_items/2024/jun/globalwafers-260624.shtml; Lorenzo Rotella, "Memc si amplia: Novara sempre di più la capitale del silicio italiana", in *La Stampa*, 9 December 2024.

[59] MIMIT, *Nasce a Pavia la Fondazione Chips.IT*, 3 November 2023, https://www.mimit.gov.it/it/notizie-stampa/nasce-a-pavia-la-fondazione-chips-it.

[60] European Commission DG for Communications Networks, *European Chips Act: Security of Supply and Resilience*, last update 4 November 2024, https://digital-strategy.ec.europa.eu/en/node/12014.

[61] European Court of Auditors, *The EU's Strategy for Microchips: Reasonable Progress in Its Implementation but the Chips Act Is Very Unlikely to Be Sufficient to Reach the Overly Ambitious Digital Decade Target*, Publications Office of the European Union, 2025, p. 7, https://www.eca.europa.eu/en/publications/SR-2025-12.

[62] Jan-Peter Kleinhans, *The Missing Strategy in Europe's Chip Ambitions. Member States Must Drive the Next Steps*, Berlin, interface, 30 July 2024, p. 14, https://www.interface-eu.org/publications/europe-semiconductor-strategy.

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domestic ecosystem and their position in the global semiconductor value chain".[63]

It could be argued that the Italian government has been up to this latter task. Both the STMicroelectronics and Silicon Box projects address concerns tied to the logic of "de-risking", albeit to the limited extent that a country like Italy with a secondary position in the global semiconductor industry could do. Much of the debate on semiconductors in the aftermath of the 2021 chip crunch and the introduction of severe controls on the export of advanced semiconductors to China by the Biden administration in October 2022 has focused on advanced chips and on the Chinese efforts to both maintain access to critical technologies and develop indigenous ones to remain technologically competitive vis-à-vis the United States. Consequently, global attention on semiconductors has centred on the technological chokepoints located at the TSMC-ASML nexus and the race to produce chips sporting increasingly smaller nodes. This is only part of the de-risking story, however.

The logic behind the race for ever-shrinking nodes rests on the so-called "Moore's Law", extrapolated by a 1975 speech by Intel co-founder Gordon E. Moore in which he posited that the ideal number of transistors per square inch on a microchip could double every two years,[64] thus guaranteeing continuing improvements in computing power, higher efficiency and the ability to execute increasingly complex functions.[65] The technological trajectory designed by Moore's Law, however, has arguably been approaching its end,[66] with physical limits to the possibility of continuing to shrink the nodes of chips in sight.[67] Against this backdrop, advanced packaging technologies, the focus of companies like Silicon Box, have been identified as a way forward to continue improving chip performance.[68] In a context in which East Asian, and specifically Taiwanese and Chinese companies dominate

63 Ibid, p. 19.

64 Gordon E. Moore, "Progress in Digital Integrated Electronics", in *Technical Digest 1975*, 1975, p. 11-13 at p. 13, https://www.eng.auburn.edu/~agrawvd/COURSE/E7770_Spr07/READ/Gordon_Moore_1975_Speech.pdf.

65 Sujai Shivakumar and Chris Borges, "Advanced Packaging and the Future of Moore's Law", in *CSIS Critical Questions*, 26 June 2023, https://www.csis.org/node/106061.

66 David Rotman, "We're Not Prepared for the End of Moore's Law", in *MIT Technological Review*, 24 February 2020.

67 M. Mitchell Waldrop, "The Chips Are Down for Moore's Law", in *Nature*, Vol. 530, No. 7589 (11 February 2016), p. 144-147, https://doi.org/10.1038/530144a.

68 As VerVey explains "The most common interconnect types used in packaging today are wire bonds (in which minuscule wires connect a chip to a PCB [printed circuit board] to transfer electronic signals). The challenge with wire bonds is that their size did not scale down at the same pace as did transistor density [...] meaning transistors contained more processing power than the wires were capable of communicating. Advanced packaging attempts to solve this problem by using new or novel interconnect approaches such as 'bumps', 'balls', or 'wafer-level packaging' rather than wires to connect chips. This minimizes package size and maximizes performance at steady to declining costs". John VerWey, "Re-Shoring Advanced Semiconductor Packaging. Innovation, Supply Chain Security, and U.S. Leadership in the Semiconductor Industry", in *CSET Policy Briefs*, June 2022, p. 8, https://cset.georgetown.edu/publication/re-shoring-advanced-semiconductor-packaging.

the outsourced packaging segment of back-end production,[69] the establishment of the new Silicon Box in Novara, a first of its kind in Europe, is a potentially meaningful piece in the wider puzzle of de-risking.

Similarly, STMicroelectronics' new hub in Catania for silicon carbide chips, while dedicated to DAO chips sporting mature nodes, should be framed within a logic of de-risking that is not captured by a narrow focus on reshoring front-end production for advanced chips. Mature chips remain essential and irreplaceable for a wide range of critical sectors such as automotive, medical devices, drones, robotics, aerospace and – crucially – defence.[70] They are projected to account for around three quarters (70-76 per cent) of global semiconductor demand in the coming years, with China already holding a significant global market share (around 30 per cent compared to the EU's 13 per cent) and accounting for 40 per cent of the global planned production expansion by 2030. The EU faces a major gap, estimated at 12.7 million wafers annually by 2030. Given that announced domestic capacity will cover only a fraction of this demand, particularly for more mature nodes, and considering China is building the most capacity globally, China-based fabs are likely to meet much of this expanding European demand, creating a new strategic dependency.[71]

It is worth noting that experts in the field have disputed trajectories resulting into a Chinese overcapacity capable of wiping out international competitors and impose dependencies similar to the ones existing in solar panels and increasingly in EVs.[72] Detailed analyses suggest, however, that the risk of strategic dependency remains considerably high at least for one type of DAO chip, power MOSFETs, due to expanding Chinese share, localisation trends and high substitutability.[73] As it happens, innovative power MOSFETs in silicon carbide are among the range of products that STMicroelectronics will produce in the new plant in Catania,[74] highlighting once again the strategic dimension of the two flagship projects. While minor, Italy's contribution to the EU's de-risking strategy is no less real.

[69] Ibid., p. 12.

[70] See Amy MackInnon, "Russia's War Machine Runs on Western Parts", in *Foreign Policy*, 22 February 2024, https://foreignpolicy.com/?p=1137925.

[71] Tim Nicholas Rühlig, "Curbing China's Legacy Chip Clout. Reevaluating EU Strategy", in *EUISS Briefs*, 21/2024 (December 2024), p. 2, https://www.iss.europa.eu/node/3313.

[72] Paul Triolo, "Legacy Chip Overcapacity in China: Myth and Reality", in *CSIS Blog*, 30 April 2024, https://www.csis.org/node/110317.

[73] Power MOSFETs (metal-oxide-semiconductor field-effect transistors) are semiconductor designed to manage high voltages and operate at fast switching speeds used in consumer electronics, radio-frequency applications, transportation technology, and the automotive sector. See: Tim Rühlig, "China's Legacy Chip Buildout: A New EU Strategic Dependency that Needs De-Risking?", in *UI Briefs*, No. 2/2025 (March 2025), p. 6, https://www.ui.se/butiken/uis-publikationer/ui-brief/2025/chinas-legacy-chip-buildout-a-new-eu-strategic-dependency-that-needs-de-risking.

[74] STMicroelectronics website: *STPOWER SiC MOSFETs*, https://www.st.com/en/power-transistors/stpower-sic-mosfets.html.

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4. Conclusion: De-risking in the semiconductor industry from Biden to Trump

Interviews with officials confirm that major economic and technological barriers continue to prevent Italy from reshoring front-end production for advanced chips, thus justifying a pivot towards mature chips, in particular DAO chips, and advanced packaging. Interviews also confirm that this pivot was explicitly linked to the perceived risk of an emerging dependency on China for mature nodes that could potentially lead to a crisis for national security, given their role in the manufacturing of weapon systems.[75] Furthermore, interviews with officials show that Italy's industrial policy on semiconductors has been articulated with an eye on the G7 as the premiere platform for cooperation, with the country playing a key role in establishing a G7 Contact Group on Chips, during its own presidency of the group in 2024.

Public G7 statements show that Italy hosted partners on 20-21 June 2024 to discuss "crisis coordination, pre-competitive research, and sustainable manufacturing".[76] Interviews reveal that the Contact Group worked extensively throughout 2024, even expanding engagement to a non-G7 country such as the Netherlands, arguably due to the crucial role of the country's industry and especially of ASML for the chip dossier, sharing a paramount concern on the perceived security threat of a dependency on Chinese mature chips.[77] A meaningful implication of this tight coordination at the G7 level, in turn, is that throughout the end of the Biden administration coordination over de-risking primarily answered to a transatlantic logic focusing on China, rather than on a narrow pursuit of more resilient supply chains for the EU.

In fact, as in virtually all areas of transatlantic and G7-level relations, the return of Donald Trump to the White House in 2025 has complicated pre-existing plans and expectations. Trump implicitly cast doubts over US interest in Taiwan's security since the early stages of his electoral campaign, repeatedly berating the island for the delocalisation of US chip-making at the turn of the century, and arguably coerced TSMC into a further expansion of its front-end facilities in Arizona through the threat of sanctions, rather than via the subsidies of the CHIPS and Science Act, in March 2025.[78] Moreover, his administration has imposed new export controls targeting the NVIDIA H20 and the AMD MI308, advanced chips that had been specifically designed to be exported to China while meeting the requirements for export controls of the Biden administration – a consequence of the unexpected

[75] Interview with Italian ministerial officials, October 2024.

[76] G7, *G7 Science and Technology Ministers' Meeting Communiqué*, Bologna and Forlì, 9-11 July 2024, https://www.g7italy.it/wp-content/uploads/G7-Science-and-Technology-Ministers-Meeting-Communique.pdf.

[77] Interview with Italian ministerial officials, October 2024.

[78] Chung Yu-chen and Lee Hsin-Yin, "Trump Softens Tone on Taiwan's Chip Industry after TSMC Investment", in *Focus Taiwan*, 8 March 2025, https://focustaiwan.tw/business/202503080007.

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success of the Chinese company DeepSeek in developing competitive AI models with less computing power.[79] Above all, as of April 2025, Trump has continued to threaten wider tariffs on chips to coerce an acceleration and expansion of the reshoring in the United States.[80] The disruption that such tariffs would impose on the still extremely fragmented supply chain of semiconductors would be daunting. Similarly, the implications that such tariffs would have for the efforts by the EU and its member states to de-risk their own semiconductor industry remain extremely difficult to examine.

Finally, broader questions are raised by China's own progress in developing its indigenous semiconductor industry and its countermeasures to US attempts to technologically blockade it. The Biden-era export controls have produced mixed-results, fuelling the "rampant stockpiling of foreign equipment […] while accelerating China's tech indigenization efforts through the two engines of its self-reliance drive – Huawei […] and SMIC".[81] In fact, the approach that the Trump administration inherited from the final export controls of the Biden administration is one that does not simply aim at preventing access to advanced chips with American IPs, but that now aspires to wholly cut off foreign assistance "to keep complex lithography, deposition, etch, and other tools running" to impede Chinese technological advancement.[82]

Beyond industrial indigenisation, Beijing has responded by gradually expanding export controls on rare earth materials, weaponising its dominant position in the supply chain for their extraction and processing of these critical minerals since 2023, with a decisive acceleration introduced in April 2025 with the introduction of special export licenses to restrict the export of rare earth magnets used in defence, energy and automotive sectors.[83] With China attempting to close existing loopholes for rare earths towards the United States,[84] the consequences for the EU semiconductor players could impose further vulnerabilities – especially in a context in which the Union's own attempt to de-risk the supply chain of critical materials is lagging behind.[85]

[79] Liza Lin and Amrith Ramkumar, "U.S. Tries to Crush China's AI Ambitions with Chips Crackdown", in *The Wall Street Journal*, 17 April 2025, https://www.wsj.com/economy/trade/trump-chip-exports-nvidia-h20-china-amd-d2c4c866. See also Bertin Martens, "How DeepSeek Has Changed Artificial Intelligence and What It Means for Europe", in *Bruegel Policy Briefs*, No. 12/25 (March 2025), https://www.bruegel.org/node/10755.

[80] Adam Maguire, "Little Fear but Much Confusion over Trump's Computer Chip Tariffs", in *RTE*, 26 April 2025, https://www.rte.ie/news/business/2025/0426/1509547-semiconductor-trump-tariff.

[81] Reva Goujon and Ben Reynolds, "Slaying Self-Reliance", cit. See also Armand Meyer et al., "Derisking Energizes China's Greenfield Chipmaking Investments", in *China Cross-Border Monitor*, 12 December 2024, https://cbm.rhg.com/node/261405.

[82] Reva Goujon and Ben Reynolds, "Slaying Self-Reliance", cit.

[83] Grace Baskaran and Meredith Schwartz, "The Consequences of China's New Rare Earths Export Restrictions", in *CSIS Critical Questions*, 14 April 2025, https://www.csis.org/node/115778.

[84] Sarah Godek, "China's Germanium and Gallium Export Restrictions: Consequences for the United States", in *Stimson Center Issue Briefs*, 19 March 2025, https://www.stimson.org/?p=106053.

[85] Joris Teer and John Seaman, "Starting with the End in Mind: De-Risked Gallium, Germanium,

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To conclude, Italy's efforts to de-risk its semiconductor industry have shown the country's capacity to fashion a clear-eyed approach to the country's position in the sector's global supply chain and produce meaningful results. Yet, Italy on its own is not capable of providing a decisive contribution to the ambitious objectives set by the European Chips Act, especially in a context in which an unpredictable and still unfolding Sino-American geo-economic competition risks precluding Europe's possibility to move towards a concrete degree of self-reliance in the medium term.

Updated 9 June 2025

and Rare Earth Value Chains by 2030", in *EUISS Intra-EU Workshop Outcomes*, 6 March 2025, https://www.iss.europa.eu/node/3318. See also Francesca Maremonti, "Reality Check: The Regulatory Dimension of the EU Derisking Strategy. The Case of Critical Raw Materials and Semiconductors", in *IAI Papers* (June 2025), forthcoming; Pier Paolo Raimondi, "EU and Italian Derisking Strategies for Energy Transition Critical Raw Materials", in *IAI Papers* (June 2025), forthcoming.

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EU and Italian De-risking Strategies for Energy Transition: Critical Raw Materials

by Pier Paolo Raimondi

Ministry of Foreign Affairs
and International Cooperation

ABSTRACT

Governments and stakeholders at large have become aware of the material dimension of the green transition. Without stable and secure supplies of critical raw materials (CRMs), the industrial transformation – underpinned by the energy and digital transition – will not happen. However, the current market structure entails strategic vulnerabilities – especially the high geographical concentration with a dominant role played by China. The EU has increasingly adapted its regulatory framework with the Critical Raw Materials Act to reduce such vulnerabilities through the development of a European value chain (extraction, processing and recycling) as well as strategic partnerships with key partners. However, a successful de-risking strategy will take time and require massive amounts of money.

Critical raw materials | *Supply chains* | *European Union* | *Italy*

keywords

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EU and Italian De-risking Strategies for Energy Transition: Critical Raw Materials

by Pier Paolo Raimondi*

Introduction

Policymakers and stakeholders at large have increasingly become aware of the material dimension of the green and digital transitions. Particularly, governments and companies have been dealing with the strategic importance of critical raw materials and minerals (CRMs), which are vital for a variety of technologies and sectors – including the clean-tech.

The combination of their economic importance and the absence of credible alternatives (especially in the short- and medium-term) dictates the urgency to ensure adequate, secure and stable supplies of these materials for many countries and companies. Steering away from fossil fuels will reduce import dependency but will not result in the complete demise of security risks. The shift towards more mineral-intensive technologies creates a new web of resource dependence with a distinct set of geopolitical and economic implications.

As decarbonisation unfolds, global energy systems will become more mineral-intensive as clean technologies like solar photovoltaic, wind farms, batteries and electric vehicles (EVs) require generally more minerals than their fossil fuel-based counterparts. Global demand for such CRMs as lithium, copper and cobalt will quadruple on average by 2040 based on International Energy Agency (IEA) estimates.[1] Demand growth will vary among minerals and technologies. For example, global demand of lithium and graphite compared to 2020 is expected to

[1] International Energy Agency (IEA), *The Role of Critical Minerals in Clean Transition*, May 2021, p. 8, https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions.

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grow up to ninety times, while neodymium and dysprosium demand is expected to grow by ten-eleven times by 2050 in a net-zero scenario.[2]

Moreover, the share of clean energy technologies in total demand for most minerals will continue its upward trend started in mid-2010s. EVs and battery storage account for 30 per cent of the total current demand for lithium, which has made them the largest consumers for that mineral ahead of consumer electronics since 2015.[3] The relevance of EVs and battery storage in the demand growth will continue. For example, their share of total demand is expected to reach over 40 per cent for copper and rare earths elements (REEs), 60-70 per cent for nickel and cobalt and almost 90 per cent for lithium by 2040 in the IEA's Sustainable Development Scenario.

Managing market fundamentals (supply-demand equilibrium) is essential to prevent potential supply disruptions and price spikes that would ultimately slow down the pace of the transition. However, the current market structure presents several barriers and risks for importing countries, starting from the high geographical concentration throughout the value chain with the dominant role of China for most of these CRMs.

The status quo is the result of geological endowment, industrial policies and the politico-economic paradigm on international trade and cooperation, dominant from the late 1980s through the early 2010s, which used to prioritise economic efficiency. However, multiple crises (e.g., Covid-19 and Russia's war on Ukraine) coupled with other growing geopolitical tensions have forced countries to analyse and reconsider their reliance on partners and countries aimed at mitigating national and economic security risks. For example, CRMs is the Achilles' heel to Europe's climate ambition as the bloc relies heavily on imports (70-100 per cent of its consumption).[4] In this transformation of priorities (economic security rather than efficiency) and US-China rivalry, competition on minerals and related supply chains has strongly emerged.[5] A 'de-risking' strategy is thus required not only to reduce potential risks but also to navigate growing fragmentation and polarisation.

According to the IEA, the combined market value of key minerals for the energy transition (copper, lithium, nickel, cobalt, graphite and REEs) is expected to more than double from today's 325 billion to 770 billion US dollars by 2040 in the net-

[2] Samuel Carrara et al., *Supply Chain Analysis and Material Demand Forecast in Strategic Technologies and Sectors in the EU. A Foresight Study*, Luxembourg, Publications Office of the EU, 2023, p. 8, https://doi.org/10.2760/386650.

[3] IEA, The Role of Critical Minerals in Clean Transition, cit., p. 5.

[4] Rüya Perincek and Andreas Goldthau, "Ensuring Europe's Supply of Critical Minerals", in *Project Syndicate*, 22 January 2025, https://prosyn.org/FYae7f3.

[5] Harry Dempsey, Camilla Hodgson and Jamie Smyth, "How Critical Minerals Became a Flash Point in US-China Trade War", in *Financial Times*, 24 April 2025, https://www.ft.com/content/aa03e3b0-606d-4106-97dc-bac8ad679131.

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zero scenario.[6] Inevitably, companies and countries are keen to seize economic opportunities, build industries, create jobs and enhance resilience. Massive amounts of investments are required, however. The IEA estimates that 360-450 billion US dollars are needed in mining and 90-210 billion in refining and processing between 2022 and 2030 in a net-zero scenario.[7]

The assessment of criticality and vulnerability differ among importer countries due to different economic structures and supply diversification. For example, the EU identified 34 minerals as critical while the Trump Administration used a wider list of about fifty, including zinc and lithium. Therefore, countries need to carefully design cooperative initiatives where possible. At the same time, mineral-rich countries have been eager to exploit their comparative advantages amidst the global competition also by imposing export restrictions to raw minerals as in the case of Indonesia' nickel industry.[8] This allows the country to develop refining and processing industries, export value-added products and collect higher returns.

Starting by mapping security risks related to CRMs, this paper looks at how the EU seeks to close potential unbalances between supply and demand by assessing different de-risking strategies, proposed in the recent Critical Raw Materials Act, with a particular focus on international cooperation with key partners. This paper also looks at how Italy is positioned in the new evolving resource competition in the context of European legislation.

1. CRMs security considerations

For importing countries, decarbonisation is increasingly embraced as an economic and energy security strategy, although they need to consider different security risks throughout the transition – including those related to CRMs. The main concern is the scarcity of resources, even though there are differences between CRMs and fossil fuels. Concerns about the latter are about absolute scarcity, while the scarcity issue of CRMs consists more of a problem of economic and geopolitical scarcity. Said otherwise, it is the affordable and reliable access to them rather than their exhaustion in the long term that worries policymakers.

This issue is strongly visible in the case of rare earth elements, minerals that are increasingly relevant to such critical industries as green technologies, defence and high tech. REEs deposits occur in many parts of the world; what defines these elements as "rare" is their low concentration: they do not occur in pure forms in

[6] IEA, *Global Critical Minerals Outlook 2024*, May 2024, p. 7, https://www.iea.org/reports/global-critical-minerals-outlook-2024.

[7] IEA, *Energy Technology Perspectives 2023*, January 2023, https://www.iea.org/reports/energy-technology-perspectives-2023.

[8] WTO, *Dispute Settlement DS592: Indonesia – Measures Relating to Raw Materials*, https://www.wto.org/english/tratop_e/dispu_e/cases_e/ds592_e.htm.

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nature but are always compounded with other elements, thus they come with a low economic incentive to exploit them. Second, fossil fuel energy security depends on a continuous supply, meaning any disruption immediately affects the functioning of the current energy system. In contrast, CRMs and clean technologies are typically manufactured and can be stockpiled, so disruptions primarily influence the speed and scale of future deployments rather than causing immediate operational impacts on the low-carbon energy system.

Delving into more specific security vulnerabilities of CRMs, the current market structure presents several sources of insecurity from the supply side – especially for newcomers, namely geographical concentration, timing, price volatility as well as political, social and environmental concerns.

Starting from a geological point of view, the main cause of concern is primarily the *high geographical concentration* of current production as it's controlled by a small handful of countries. The top three producers of lithium, cobalt and REEs hold well over three-quarters of global output (figure 1).

Figure 1 | Largest producers of cobalt, lithium and REEs in 2023

Source: Author's elaboration on IEA, *Global Critical Minerals Outlook 2024*, cit.

Single countries can also account for over half of worldwide production, such as South Africa in the case of platinum and Democratic Republic of the Congo (DRC) with cobalt in 2019. Such concentration is likely to remain unchanged until 2040 based on the current pipeline of projects (figure 2). At the same time, data show that diversification strategies are increasingly generating results with new deposit found across the globe, with the consequent rise of new players and a reduction of China's share in certain minerals.[9]

[9] Jared Cohen, Wilson Shirley and Klara Svensson, "Resource Realism: The Geopolitics of Critical Mineral Supply Chains", in *Goldman Sachs Insights*, 13 September 2023, https://www.goldmansachs.com/insights/articles/resource-realism-the-geopolitics-of-critical-mineral-supply-chains.

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Figure 2 | Geographical concentration of mining

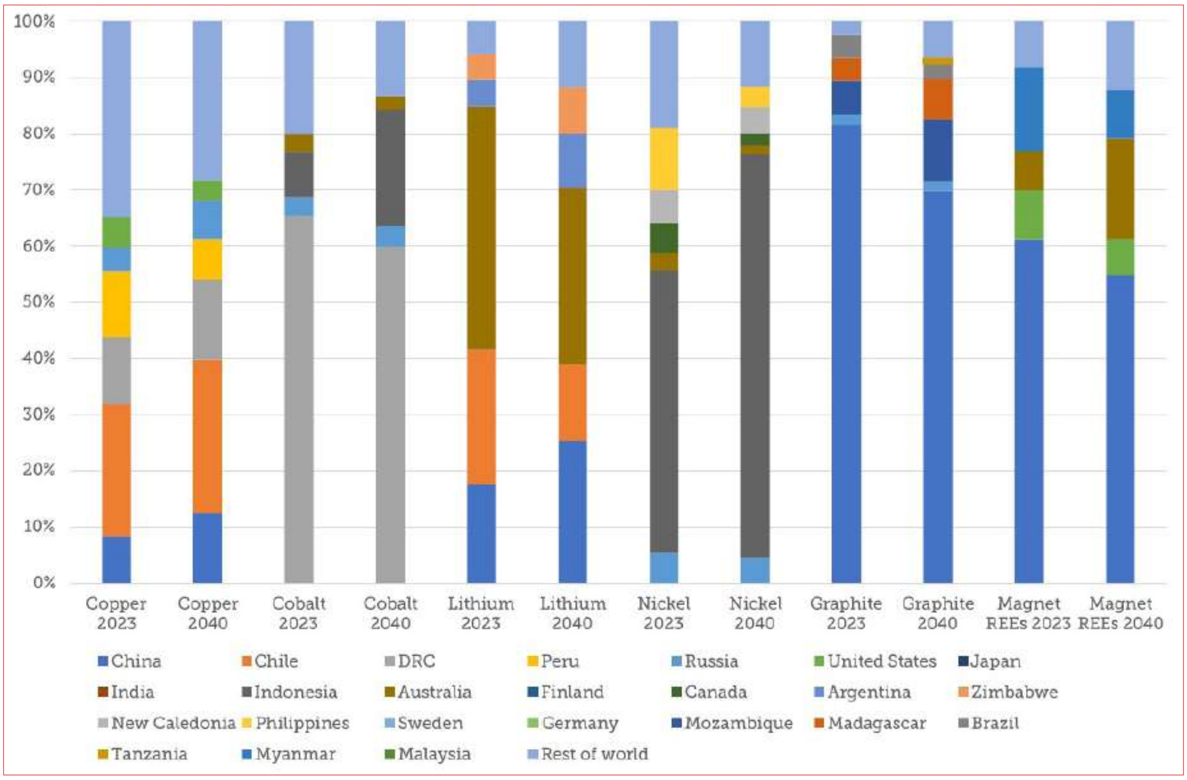
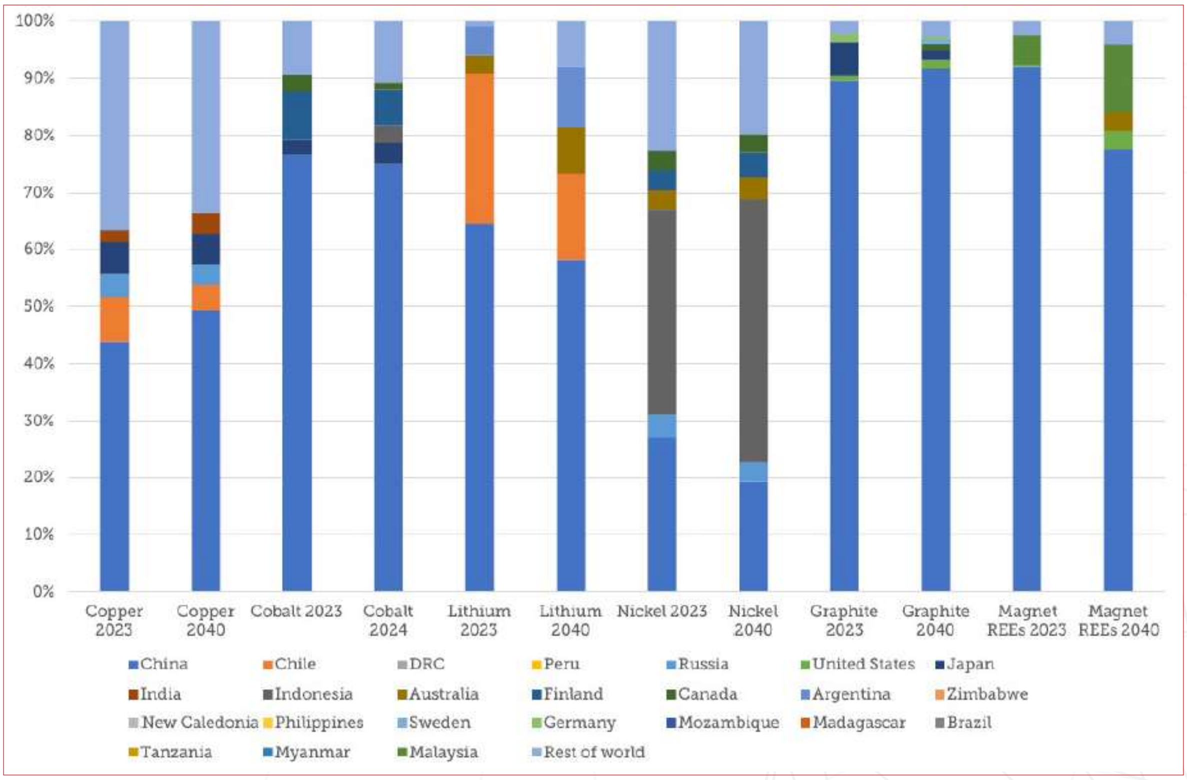


Figure 3 | Geographical concentration of refining



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Geology and natural endowment are only one part of the equation as geographical concentration is even more pronounced along the entire value chain, highlighting the implications of industrial policy. China has become the cornerstone of refining and processing for many of these minerals even when it plays a limited role in the upstream. China's share of refining is around 35 per cent for nickel, 50-70 per cent for lithium and cobalt, and 90 per cent for REEs (figure 3).

China has managed to gain such geostrategic advantage thanks to decades of consistent policy planning and support, economies of scales, relaxed environmental regulations and the role of stated-owned enterprises both at home and internationally. China's dominant role across the board underlines the need for importing countries to focus their diversification efforts not only in the upstream but throughout the entire value chain. With lack of adequate refining and processing capacity at home or in like-minded countries, importers will still need to export their raw materials to China.

Moreover, it is noteworthy also to view the geographical concentration issue through the lens of asset ownership, which is slightly different. For example, European and US companies generally play a major role for copper and lithium supplies, while Chinese companies have a greater role for nickel and cobalt production in key producing countries, like Indonesia for nickel and DRC for cobalt. Indeed, Chinese companies own or have a financial stake in fifteen of the DRC's nineteen cobalt-producing mines, accounting for half of the DRC's cobalt production in 2020.[10] This is the result of a twenty-year-period of growing investment. In 2020, China had an FDI stock of 3.7 billion US dollars in the DRC, most of which is supposed to be directed at the mining sector. This trend shows how Chinese companies generally have greater tolerance for working and investing in challenging environments.[11]

Given the dominant role of China, the member countries of the Organisation for Economic Cooperation and Development (OECD) have expressed growing concerns about the potential weaponisation of CRMs supplies. The first episode occurred in 2010, when Beijing halted REEs exports to Japan because of a political dispute,[12] which was a wakeup call for all importing economies. The embargo was lifted after importing countries filed a complaint to the World Trade Organisation (WTO). However, China has continued to coercively restrict its supplies and

[10] Suleyman O. Altiparmak et al., "Cornering the Market with Foreign Direct Investments: China's Cobalt Politics", in *Renewable and Sustainable Energy Transition*, Vol. 7 (June 2025), Article 100113, https://doi.org/10.1016/j.rset.2025.100113.

[11] Wenjie Chen, David Dollar and Heiwai Tang, "Why Is China Investing in Africa? Evidence from the Firm Level", in *The World Bank Economic Review*, Vol. 32, No. 3 (2018), p. 610-632, https://hdl.handle.net/10986/33529.

[12] Keith Bradsher, "Amid Tensions, China Blocks Vital Exports to Japan", in *The New York Times*, 22 September 2010, https://www.nytimes.com/2010/09/23/business/global/23rare.html.

technologies. It blocked its graphite exports to Sweden in 2021[13] and imposed growing export restrictions on REEs, gallium, germanium and graphite as well as some REEs technology towards the United States and other countries as the ongoing trade war escalates.[14]

Given the economic and strategic opportunities of decarbonisation, new players have been attempting to enter the market, like Saudi Arabia and other Gulf Cooperation Council (GCC) countries.[15] Besides investing in domestic mineral capacity, these countries have increased their global footprint through overseas investments – potentially making them key partners in the diversification efforts. Their international presence is likely to expand due to their substantial financial resources combined with greater political acceptance from mineral-rich countries in light of less strings attached compared to European investments.[16]

Actions aimed at diversifying the global mineral value chains face several fundamental constraints. First, climate and industrial targets are supposed to be met by 2030, which means that new mineral supplies are needed in the short term. This leads to a second constraint, related to mining operations. While actions must be taken now, governments will have to deal with long procedures for opening new mines – on average ten-fifteen years. To sustain investment levels in new mining activities, companies and governments face another major risk: *price volatility*. As any capital-intensive industries, the mining sector requires price stability and enough price incentives to attract investments. Unfortunately, volatility has become a defining feature of several minerals markets – especially for those essential for EVs. Since 2021, all commodities markets have recorded a rising trend due to inflationary waves and constrained supplies. However, over the past two years prices have dropped (figure 4) because of the combination of new supply coming online, and slower clean tech demand (e.g., EVs).[17] Therefore, lithium prices have experienced substantial fluctuations in the past two years. Similarly, cobalt prices surged by over 100 per cent in 2021 only to fall by 30-40 per cent in 2022 and 2023.

[13] Economist, "Why Is China Blocking Graphite Exports to Sweden?", in *The Economist*, 22 June 2023, https://www.economist.com/business/2023/06/22/why-is-china-blocking-graphite-exports-to-sweden.

[14] Siyi Liu and Dominique Patton, "China Bans Export of Rare Earths Processing Tech over National Security", in *Reuters*, 22 December 2023, https://www.reuters.com/markets/commodities/china-bans-export-rare-earths-processing-technologies-2023-12-21.

[15] Gracelin Baskaran, "Partnering with Middle Eastern Countries to Boost US Minerals Security", in *CSIS Commentaries*, 6 September 2024, https://www.csis.org/node/112225.

[16] Diana-Paula Gherasim, "The Troubled Reorganization of Critical Raw Materials Value Chains. An Assessment of European De-risking Policies", in *IFRI Papers*, September 2024, https://www.ifri.org/en/node/50563.

[17] Gracelin Baskaran, "Drivers of Base Metals Price Volatility", in *CSIS Commentaries*, 7 June 2024, https://www.csis.org/node/110951.

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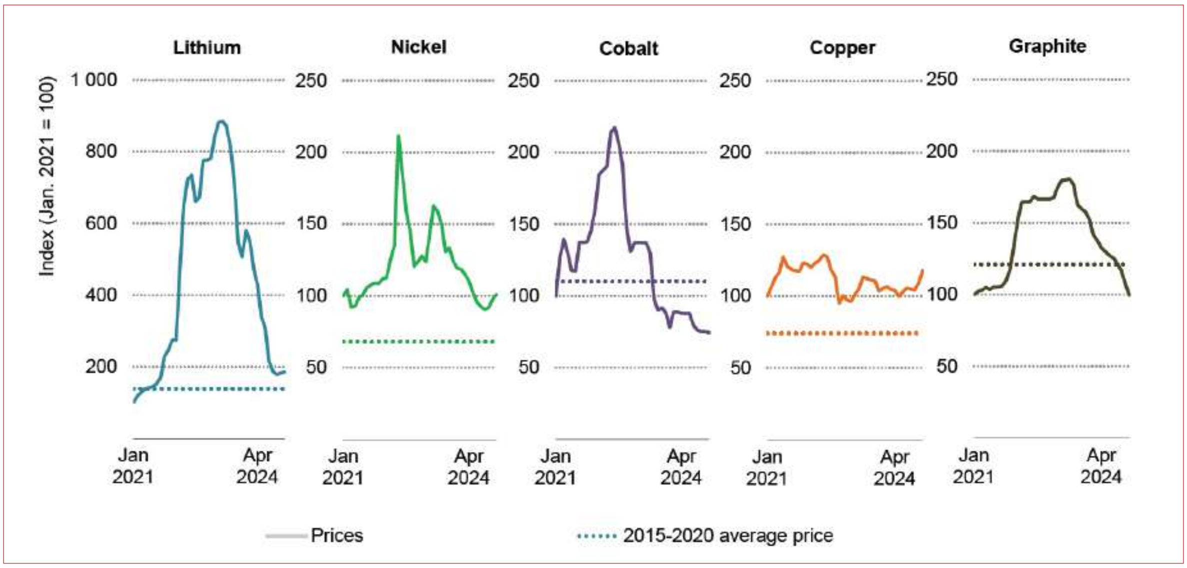
Figure 4 | Critical minerals prices, 2021-2024



Source: IEA, *Global Critical Minerals Outlook 2024*, cit., p. 38.

High price volatility entails different consequences for both consumers and producers. While consumers may benefit from low clean tech prices, these discourage new investments. Conversely, producers can collect higher windfall at high minerals prices even though they could see a demand reduction and the advent of new investments outside their country. This was particularly visible in the case of China's 2010 export ban on REEs to Japan, which spurred a wave of new investments and diversification efforts that resulted in the reduction of China's share in world's REEs reserves from 50 per cent in 2012 to 34 per cent in 2022.[18] Nonetheless, China can leverage its dominant position in both ways: either by restricting exports pushing upward prices and inflicting economic pain to its competitors as in the case of REEs and graphite against the United States; or by flooding the market depressing prices and affecting the profitability of new and alternative projects, as in the case of nickel.[19]

Despite the recent price drop, governments cannot overlook security of supply because of a growing wave of resource nationalism and export restrictions. The economic and geopolitical incentives have induced a rising number of countries to tighten control over mineral exports, including exports ban on raw materials with the clear objectives to incentivise local processing and ensure higher returns.[20]

[18] Jared Cohen, Wilson Shirley and Klara Svensson, "Resource Realism", cit.

[19] Gracelin Baskaran, "Drivers of Base Metals Price Volatility", cit.

[20] Przemyslaw Kowalski and Clarisse Legendre, "Raw Materials Critical for the Green Transition. Production, International Trade and Export Restrictions", in *OECD Trade Policy Papers*, No. 269 (April 2023), https://www.oecd.org/en/publications/raw-materials-critical-for-the-green-transition_c6bb598b-en.html.

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This was the case for Zimbabwe with lithium and Indonesia with nickel.[21] Other mineral-rich countries are reconsidering nationalising the mining industry. As of today, mineral-rich countries have not yet created cartels, like the Organisation of Petroleum Exporting Countries (OPEC), to coordinate output strategies in order to sustain mineral prices Still, key producers, especially those with high dependence on minerals exports, could decide to pursue this strategy for economic reasons; in early 2025, the DRC decided to ban for four months its cobalt exports due to oversupplied markets.[22] Other countries, like India, Argentina, Senegal, Vietnam and Kazakhstan, have introduced some export restrictions. Among these countries, China stands out with a wide range of export control measures for several REEs and graphite against the United States and other countries, motivated by a desire to retaliate against US tariffs and high-tech export controls.[23] As result, export restrictions on critical minerals have increased five times in the past fifteen years.[24]

The efforts to diversify suppliers and create alternative value chains clash with the potential social and environmental negative consequences. Mining and refining activities are characterised by high environmental footprint.[25] For example, the operations required for bauxite in Australia, REEs in China as well as copper and lithium in Chile have a high biodiversity impact. Overlooking these aspects undermines the political and financial acceptability of new projects. Additionally, companies may encounter local opposition and concerns for certain activities also due to water use as mining critical minerals, like lithium, is highly water intensive.[26] Furthermore, it is essential to ensure sufficient labour protection – especially for the most vulnerable groups like minors and indigenous people.[27] At the same time, diversification efforts and strategies need to consider how climate change may affect future projects. According to some estimates, over 70 per cent of cobalt and lithium production could face significant, high or extreme drought risks:[28] these trends may disrupt mining operations especially given the high geographical

[21] "Zimbabwe Bans Raw Lithium Exports to Curb Artisanal Mining", in *Reuters*, 21 December 2022, https://www.reuters.com/world/africa/zimbabwe-bans-raw-lithium-exports-curb-artisanal-mining-2022-12-21.

[22] Ange Aidhe Kasongo and Sonia Rolley, "Congo Bans Cobalt Exports for Four Months to Curb Oversupply", in *Reuters*, 25 February 2025, https://www.reuters.com/markets/commodities/congo-suspends-cobalt-exports-four-months-counter-oversupply-bloomberg-news-2025-02-24.

[23] Shobhan Dhir, Eric Buisson and Tae-Yoon Kim, "Growing Geopolitical Tensions Underscore the Need for Stronger Action on Critical Minerals Security", in *IEA Commentaries*, 9 February 2025, https://www.iea.org/commentaries/growing-geopolitical-tensions-underscore-the-need-for-stronger-action-on-critical-minerals-security.

[24] Przemyslaw Kowalski and Clarisse Legendre, "Raw Materials Critical for the Green Transition", cit.

[25] UN Environment Programme (UNEP) Finance Initiative, "Climate Risks in the Metals and Mining Sector", in *Sectoral Risk Briefings*, May 2024, https://www.unepfi.org/?p=75823.

[26] Wetlands International, *World Water Day: The Water Impacts of Lithium Extraction*, 22 March 2023, https://europe.wetlands.org/?p=2193.

[27] UN Department of Economic and Social Affairs (UNDESA), "Harnessing the Potential of Critical Minerals for Sustainable Development", in *World Economic Situation and Prospects 2025*, January 2025, p. 43-90, https://doi.org/10.18356/9789211070866c007.

[28] PWC, *Climate Risks to Nine Key Commodities. Protecting People and Prosperity*, 2024, https://www.pwc.com/gx/en/issues/esg/how-does-climate-change-affect-natural-resources.html.

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concentration – not only at the national level, but also at the subnational level. Indeed, activities are concentrated in a limited number of locations within those countries: just five mines in the DRC produced most of the world's cobalt in 2020 and 81 per cent of the world's lithium is sourced from no more than ten mines.[29]

2. The European response: The CRM Act

EU efforts for secure CRM supply chains date to 2008, when the Union launched the Raw Materials Initiative.[30] The 2010 REEs ban against Japan imposed by China reinforced further the need to address overdependency. In 2011, the Commission created a list of CRMs for the European economy, which is regularly reviewed and updated. Indeed, the list was updated in 2014, 2017, 2020 and 2023. Over the decade, the number of CRMs under the list grew from fourteen in 2011 to 34 in the latest update in 2023. The expansion of minerals included in the EU list highlights the evolving relevance of critical minerals given the evolution of economic and industrial priorities. In 2020, the European Raw Materials Alliance was established with the goal of enhancing resilience and strategic autonomy for Europe's rare earth and magnet value chains by bringing together all relevant stakeholders.

Rising concerns are dictated by the combination of high import reliance and expected demand growth due to climate targets. In most of the cases, the EU is dependent on imports from non-EU countries (figure 5). For example, China is responsible for 100 per cent of EU's supply of heavy REEs, Turkey supplies 99 per cent of boron, South Africa 71 per cent of the EU's needs for platinum and an even larger share of iridium, rhodium and ruthenium. In light of this overdependence on imports, the EU needs to pursue a strategy to mitigate potential risks.

[29] Ibid.

[30] Arthur Leichthammer, "Mining for Tomorrow: The Strategic Importance of Critical Raw Materials for Europe's Industry", in *Jacques Delors Centre Policy Positions*, 21 May 2024, https://www.delorscentre.eu/en/publications/detail/publication/mining-for-tomorrow.

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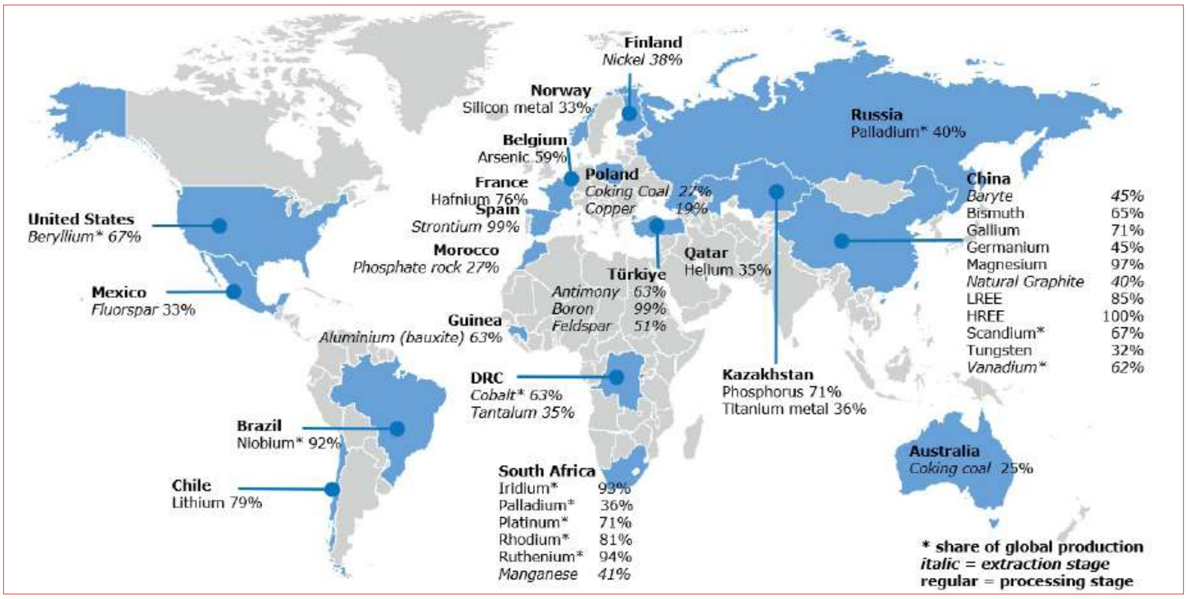
Figure 5 | World map of the main CRM suppliers to the EU (2023)



Source: Milan Grohol and Constanze Veeh, *Study on the Critical Raw Materials for the EU 2023. Final Report*, Luxembourg, Publications Office of the EU, 2023, p. 10, https://doi.org/10.2873/725585.

Such strategy is needed because of EU's climate ambition. As result of the European Green Deal, indeed, the EU demand for CRMs is expected to increase significantly. According to Joint Research Centre forecast, the EU's demand is expected to skyrocket for many key CRMs in a high demand scenario (table 1).

Table 1 | EU material demand forecast examples, high demand scenario, compared with 2020 level

	EU demand in 2030	EU forecast demand in 2050
Lithium	X 12	X 21
Graphite	X 14	X 26
Nickel	X 10	X 16
Dysprosium	X 6	X 7
Neodymium	X 5	X 6
Platinum	X 30	X 200
Aluminium	X 4	X 6

Source: Samuel Carrara et al., *Supply Chain Analysis and Material Demand Forecast*, cit.

In 2022-23, the EU considered the material side of its industrial policy. Therefore, the adoption of the EU Net-Zero Industry Act, which sets ambitious manufacturing targets for selected strategic clean technologies, was coupled with the adoption of

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the EU Critical Raw Materials Act within the Green Deal Industrial Plan.[31] The CRM Act seeks to strengthen European strategic autonomy and economic reliance in line with the 2050 climate targets. The Act also creates a monitoring mechanism to mitigate the supply chain bottlenecks. Furthermore, it introduces different concepts for critical raw materials and strategic raw materials or SRMs (table 2). CRMs refer to materials characterised by a high risk of supply disruptions and their importance for the overall EU economy, while SRMs (seventeen out of 34 minerals in the list) are characterised by their importance for strategic areas including renewables, their projected demand growth and current supply as well as the difficulties of scaling up production. The de-risking strategy is pursued through the creation of a local European value chain and diversification of import routes.

Table 2 | List of strategic (bold) and critical raw materials according to the EU CRM Act

Antimony	Arsenic	**Bauxite/ aluminium**	Baryte	Beryllium
Bismuth	Boron – **metallurgy grade**	**Cobalt**	Coking coal	**Copper**
Feldspar	Fluorspar	**Gallium**	**Germanium**	Hafnium
Helium	HREEs	LREEs	Lithium – **battery grade**	Magnesium **metal**
Manganese – **battery grade**	Graphite – **battery grade**	Nickel – **battery grade**	Niobium	Phosphate rock
Phosphorus	**Platinum group metals**	Scandium	**Silicon metal**	Strontium
Tantalum	**Titanium metal**	**Tungsten**	Vanadium	**REEs for permanent magnets** (Nd, Pr, Tb, Dy, Gd, Sm, and Ce)

Source: Author's elaboration on Annex 1 of: European Parliament 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*, http://data.europa.eu/eli/reg/2024/1252/oj.

2.1 The domestic dimension

The CRM Act sets ambitious benchmarks for the EU annual consumption by 2030: 10 per cent from local extraction; 40 per cent to be processed in the EU; and 25 per cent from recycled materials. As for domestic production, in the EU there are ideally mineral resources. Portugal is home to for instance, lithium. Europe's largest REEs deposit was found in the Kiruna area in northern Sweden in January 2023.[32] However, these resources have been overlooked due to lack of

[31] European Commission, *The Green Deal Industrial Plan: Putting Europe's Net-Zero Industry in the Lead*, 1 February 2023, https://ec.europa.eu/commission/presscorner/detail/en/ip_23_510.

[32] LKAB, *Europe's Largest Deposit of Rare Earth Metals Located in Kiruna Area*, 12 January 2023, https://lkab.com/en/press/europes-largest-deposit-of-rare-earth-metals-is-located-in-the-kiruna-area.

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political commitment, social opposition and environmental concerns. To harness this potential, the Act allows certain projects to be designated as 'strategic', which would benefit from streamlined permitting processes. According to the Act, the permit-granting process will not exceed 27 months for extraction projects and fifteen months for others. As of today, permitting processes can last from five to ten years. To be considered as 'strategic', a project must make a meaningful contribution to the security of the EU supply of strategic raw materials as well as their sustainability. In March 2025, the Commission unveiled the first round of 47 Strategic Projects in Europe, covering fourteen of the seventeen strategic raw materials, with an expected overall capital investment of 22.5 billion euros.[33] These projects are located across thirteen member states and cover one or more segments of the value chain.[34]

Alongside extracting and refining minerals, the EU pays great attention to recycling. Through it, the EU could reconcile energy security with climate objectives by reducing extraction needs. Furthermore, recycling could be an economic opportunity. The EU is already at the forefront of the circular economy. More than 50 per cent of some metals (zinc and platinum) are recycled and cover more than 25 per cent of the EU's consumption. However, secondary production contributes only marginally for those needed for clean technologies (REE, gallium or indium).[35]

Lastly, the Act is considering measures to pool demand and establish mineral stockpiling to reduce its exposure to potential supply disruptions and price spikes. Estimates consider that the initial capital needed to accumulate a stockpile of one-year worth of the five critical minerals where China is the main source would be below 0.5 billion euros.[36]

2.2 International dimension

Autarky is neither possible nor desirable as it would entail too high costs and the EU does not have enough mineral resources to satisfy its consumption. Therefore, security of supply through diversification is essential. In this sense, the Act stipulates that no single third country can supply more than 65 per cent of EU annual consumption of each strategic raw material at any relevant stage of processing. Based on this threshold, eight elements are considered as particularly

[33] European Commission, *Commission Selects 47 Strategic Projects to Secure and Diversify Access to Raw Materials in the EU*, 25 March 2025, https://ec.europa.eu/commission/presscorner/detail/en/ip_25_864.

[34] 25 projects extraction activities, 24 processing, 10 recycling and 2 substitution.

[35] Milan Grohol and Constanze Veeh, *Study on the Critical Raw Materials for the EU 2023. Final Report*, Luxembourg, Publications Office of the EU, 2023, https://doi.org/10.2873/725585.

[36] Daniel Gros, "A European Sovereignty Fund. Investing in Europe's Future and Security", in *EPRS In-Depth Analysis*, July 2024, https://www.europarl.europa.eu/thinktank/en/document/IPOL_IDA(2024)760229.

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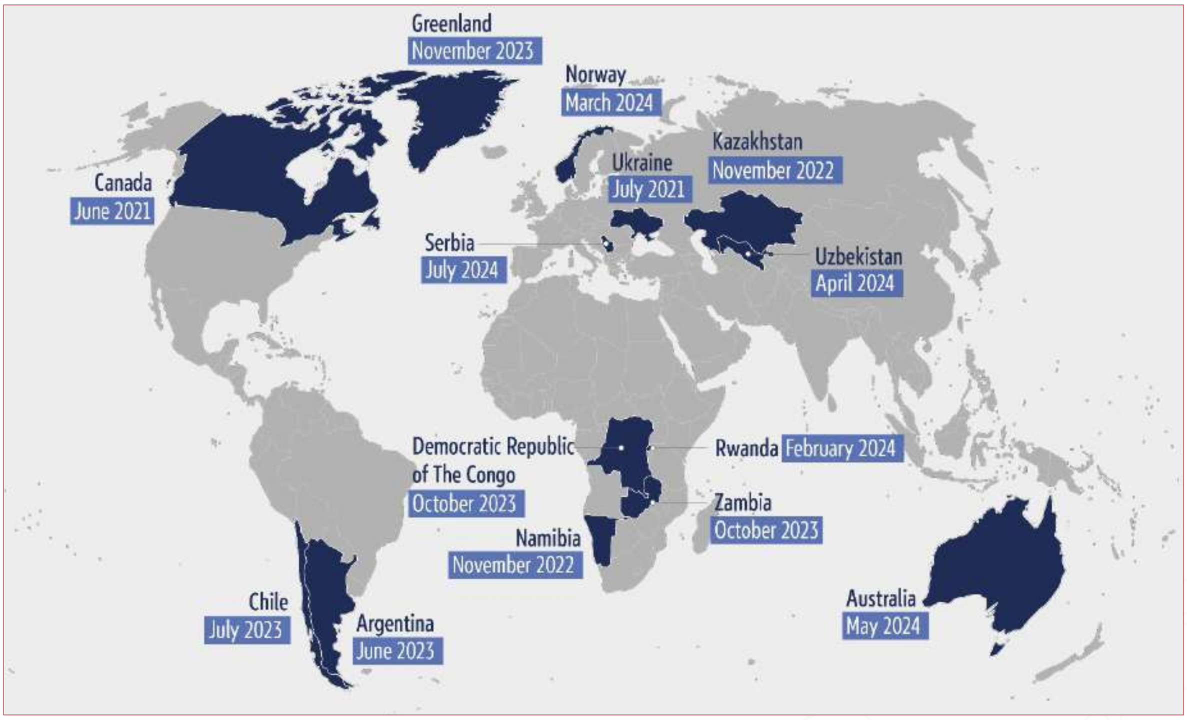
problematic.[37] Supplies from China for bismuth, cobalt ore, magnesium, manganese and strontium are all above the 65 per cent threshold. Similar levels are recorded also for borates and feldspar from Turkey and beryllium from the United States.

This 65 per cent threshold embodies the de-risking approach (rather than the decoupling) by accepting current market and economic conditions. In this sense, supply diversification and international cooperation are essential. Among the measures proposed by the Commission, two are particularly relevant: the expansion of strategic partnerships and the creation of a critical raw materials club.

Figure 6 | Strategic partnerships signed by the EU



Source: Guillaume Ragonnaud, "Implementing the EU's Critical Raw Materials Act", in *EPRS Briefings*, November 2024, p. 7, https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2024)766253.

The EU has expanded the establishment of strategic partnerships as it sets to continue to rely on imports. The EU Raw Material Diplomacy has led to the establishment of around fourteen strategic partnerships with different countries across the globe (figure 6).[38] African countries have gained a renewed political relevance and attention, with several partnerships or memoranda of understanding

[37] Marie Le Mouel and Niclas Poitiers, "Why Europe's Critical Raw Materials Strategy Has to Be International", in *Bruegel Analysis*, 5 April 2023, https://www.bruegel.org/node/8941.

[38] European Commission DG for Internal Market website: *Raw Materials Diplomacy*, https://single-market-economy.ec.europa.eu/node/481_en.

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(MoUs) signed.[39] For instance, the EU signed strategic partnerships with Namibia in November 2022, the DRC and Zambia in October 2023 and Rwanda in February 2024. It has also strengthened cooperation with other like-minded players, like Canada, Greenland and Norway. Besides holding important reserves, this latter set of countries can ensure higher social and environmental standards and lower political risks.

The EU's external approach varies significantly from those adopted by the other two major economies: the United States and China. While China has mainly invested and struck deals for raw materials, the United States has tried to sign mineral deals in exchange for security, as in the cases of Ukraine and the DRC.[40] By contrast, the EU tries to move away from a transactional approach by promising joint and shared projects with its partners – especially in developing economies. By embracing such a more holistic approach, which includes mitigation, adaptation, regeneration and socioeconomic transformation, the EU could positively boost its climate diplomacy and enhance mineral security.[41] This vision is also visible with the proposal of a Critical Raw Materials Club, where resource-hungry and resource-rich countries collaborate in diversifying the CRM value chain.[42]

In June 2025, the Commission announced the first thirteen strategic projects located outside the EU; more specifically seven are located in countries with whom the EU has already a strategic partnership (Canada, Greenland, Kazakhstan, Norway, Serbia, Ukraine and Zambia), while the remaining ones are located in Brazil, Madagascar, Malawi, New Caledonia, South Africa and the United Kingdom.[43] These "13 Strategic Projects" are expected to need an overall capital investment of 5.5 billion euros to start operations.

2.3 Italy's response

Italy has taken a few initial but important steps to address all the criticalities related to minerals. In June 2024, the Italian government adopted a 'decree-law'[44] to

[39] Margherita Bianchi, "Diplomacy in the Era of Critical Minerals", in *World Energy Magazine*, No. 60 (March 2024), p. 38-42, https://www.eni.com/static/en-IT/world-energy-magazine/race_for_minerals.html.

[40] Patrick Schröder and Armida van Rij, "Trump May Not Listen, but the US Should Cooperate with the EU on Ukraine's Minerals", in *Chatham House Expert Comments*, 17 March 2025, https://www.chathamhouse.org/node/36208; "The Guardian View on Donald Trump's Congo Deal: Mineral Riches for Protection", in *The Guardian*, 13 April 2025, https://www.theguardian.com/p/x22ned.

[41] Olivia Lazard, "How the EU Can Use Mineral Supply Chains to Redesign Collective Security", in *Strategic Europe Commentaries*, 1 June 2023, https://carnegieendowment.org/europe/strategic-europe/2023/06/how-the-eu-can-use-mineral-supply-chains-to-redesign-collective-security.

[42] European Commission, *2023 State of the Union Address by President von der Leyen*, 13 September 2023, https://ec.europa.eu/commission/presscorner/detail/en/speech_23_4426.

[43] European Commission, *Commission Selects 13 Strategic Projects in Third Countries to Secure Access to Raw Materials and to Support Local Value Creation*, 4 June 2025, https://ec.europa.eu/commission/presscorner/detail/en/ip_25_1419.

[44] A decree-law is an executive act with the force of law which however has to be converted into

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align the country's legislative framework with the EU's one.[45] This development was needed as Italy's mining sector was regulated by a decree passed in the 1920s. However, the 2024 decree does not overrule the 1927 decree,[46] which needs to be updated especially regarding the environmental sustainability of the mining sector.

The new piece of legislation adopts a holistic approach, with the aim of streamlining the governance of CRM mining. On the demand side, the state has established a monitoring mechanism of strategic industries to assess current and future mineral demands. This is instrumental to conduct stress tests and evaluate the need of potential stockpile. On the supply side, the government has conducted a mapping of existing mineral resources. As of today, there are 76 operating mines, but in many parts of the country (Latium, Tuscany, Sardinia) there is significant potential for extracting lithium, copper, manganese, tungsten, cobalt, magnesite, REEs and others.[47] These resources could reduce Italy's high import reliance. Despite the fact that it is limited in terms of volumes, foreign dependence poses a threat to Italy's industrial competitiveness. For instance, a halt to imports of gallium, indium, tungsten (for a combined value of less than 100 million euros) could threaten over 35 billion euros of industrial production in key sectors.[48] Rising domestic production is thus essential for industrial competitiveness. However, these reserves have not been developed due to economic and environmental reasons.

To sustain the rebirth of its mining industry, Italy has established a strategic fund, endowed with 1 billion euros. This fund is similar to other European countries' financial instruments: Germany's 1 billion euro fund (KfW) and France's InfraVia (endowed by 2 billion euros). However, the Fund does not cover the entire value chain with a clear focus on extraction.

Besides mining activities, Italy has a great potential for recycling, including from mining waste, as recognised by the Commission in the first round of strategic projects: all four projects located in Italy are related to recycling activities of key minerals.

actual law by parliament within sixty days. It was later converted into actual law in August 2024.

[45] Decree Law No. 84 of 25 June 2024: *Disposizioni urgenti sulle materie prime critiche di interesse strategico*, https://www.normattiva.it/uri-res/N2Ls?urn:nir:stato:decreto.legge:2024-06-25;84.

[46] Domenico Savoca, "La normativa italiana sui minerali critici: come garantire un ruolo al nostro paese", in *RiEnergia*, 13 June 2024, https://rienergia.staffettaonline.com/articolo/35507/La+normativa+italiana+sui+minerali+critici:+come+garantire+un+ruolo+al+nostro+paese/Savoca.

[47] "La mappa delle materie prime critiche in Italia", in *QualEnergia*, 25 July 2024, https://www.qualenergia.it/?p=537945.

[48] Iren, Osservatorio RigeneRARE and TEHA Group, *La roadmap italiana per le materie prime critiche*, 4 November 2024, https://www.ambrosetti.eu/news/la-roadmap-italiana-per-le-materie-prime-critiche.

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Italy has increasingly worked on international partnerships, including with key European countries like France and Germany in 2023.[49] It has also joined multilateral initiatives, like the US-led initiative Mineral Security Partnership (MSP). Furthermore, it has established bilateral partnerships with Saudi Arabia, Egypt and Canada. These efforts can merge into the Italian foreign policy flagship initiative, the so-called Mattei Plan. The Plan aims to make Italy a bridge between EU and Africa by providing win-win partnerships. The greater focus on Africa provides new opportunities to design future collaboration projects. The Mattei Plan is endowed with 5.5 billion euro funds, which could be increased with resources from the Strategic fund.

3. Assessing EU de-risking strategy: Way forward

The EU's de-risking strategy addresses serious trade-offs and may be ultimately undermined by key shortfalls, particularly on the financial resources side. Although removing red tape is very much welcome, it is equally true that Europe will require significant amount of time to get any meaningful results. Regulatory measures, either through circular targets or shorter permitting times, will not be enough. New financial tools will be needed. To achieve any target, the EU faces a dilemma regarding economic security, fiscal discipline and leading industrial capacity.

Higher economic security entails a security premium to the already high capital investments required by the mining sector. For instance, the Commission estimated that a 27.9 billion euro investment by 2030 and 52.2 billion by 2040 are required to extract 100 per cent of its lithium demand for batteries domestically.[50] The investment need would drop to 7 billion euros by 2030 and 13.1 billion by 2040 in case of a 25 per cent target for production of raw materials needed for batteries. According to Eurometaux, meeting EU goals will require the opening of at least ten new mines, fifteen processing plants, and fifteen recycling plants.[51] However, the CRM Act fails to establish the financial power required to reach the different targets. Without adequate financial support, companies will be reluctant to invest in new projects – especially given the recent price drop.[52]

[49] Italian Ministry of Enterprises and Made in Italy, *Materie prime critiche: Italia, Germania e Francia concordano una stretta cooperazione nei settori dell'estrazione, della lavorazione e del riciclo*, 26 June 2023, https://www.mimit.gov.it/it/notizie-stampa/materie-prime-critiche-italia-germania-e-francia-concordano-una-stretta-cooperazione-nei-settori-dellestrazione-della-lavorazione-e-del-riciclo.

[50] Max Münchmeyer, *Strategic Security andCritical Raw Materials: The Role of the European Investment Bank*, Rome, IAI, July 2023, https://www.iai.it/en/node/17351.

[51] EIT RawMaterials, *Why Europe Must Act Now to Change Public Perception of Mining*, 10 October 2024, https://eitrawmaterials.eu/node/2229.

[52] Francesco Findeisen and Yann Wernert, "Meeting the Costs of Resilience: The EU's Critical Raw Materials Strategy Must Go the Extra Kilometer", in *Jacques Delors Centre Policy Briefs*, 30 June 2023, https://www.delorscentre.eu/en/publications/eu-critical-raw-materials.

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The absence of any new, credible funding program is more striking if compared to that of other major economies like the United States and China. Indeed, China has worked relentlessly to provide financial assistance to its state-owned companies and producing countries to ensure enough supply. For its part, the United States has allocated over 8.5 billion US dollars for CRM projects under the 2022 US Inflation Reduction Act. A recent executive order issued by the Trump Administration on critical minerals aims to further boost financial support – with a clear domestic focus.[53]

These projects will require a combination of public investments, equity and de-risking tools like investments guarantee support including the operating costs (OpEx) via tax subsidy.[54] As of today, the EU taxonomy includes only recycling of critical minerals. Thus, the EU should revise its taxonomy by adding mining and refining activities under the conditions of high environmental standards. This could help channel and attract private investments. Additionally, such approach would be very much welcomed also for the international dimension. The EU faces growing competition vis-à-vis other countries in the international mineral markets. The political commitment should be complemented by enough financial capabilities – also in challenging contexts. The case of Japan Organisation for Metals and Energy Security (JOGMEC) is particularly valid. At the same time, the EU can expand the use of market-based instruments such as contracts for difference and cap-and-floor models to stabilise costs and support off-takers.[55] Lastly, public resources should be channelled to research and development, training and upskilling programmes.[56]

Furthermore, the CRM Act sets unconditional targets for all minerals included in the list. A more granular analysis would be welcomed to inform policymakers and companies of the measures needed for enhancing EU economic security. Through better data and communication, the EU should outline which minerals can be outsourced and which ones are critical to produce domestically based on strategic and economic criteria.

The EU ambitions to expand mineral extraction and refining capacity may conflict with its stringent environmental standards and regulations. For instance, the EU biodiversity strategy sets a target for 2030 to protect at least 30 per cent of its land and sea areas, potentially restricting future mining operations. Furthermore, political opposition to mining projects has intensified, particularly concerning

[53] Alexis Harmon and Reed Blakemore, "Four Critical Questions (and Expert Answers) about Trump's New Critical Minerals Executive Order", in *New Atlanticist*, 21 March 2025, https://www.atlanticcouncil.org/?p=835234.

[54] Diana-Paula Gherasim, "The Troubled Reorganization of Critical Raw Materials Value Chains", cit.

[55] IEA, *Global Critical Minerals Outlook 2025*, May 2025, https://www.iea.org/reports/global-critical-minerals-outlook-2025.

[56] Luis Tercero Espinoza et al., "The Role of Research and Innovation in Ensuring a Safe and Sustainable Supply of Critical Raw Materials in the EU", in *EPRS Studies*, July 2024, https://www.europarl.europa.eu/thinktank/en/document/EPRS_STU(2024)762848.

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the environmental impacts of proposed large-scale lithium mining projects – for instance in neighbouring Serbia.[57] These concerns highlight the need for a comprehensive revision of the existing mining paradigm.

Furthermore, to ensure a sustainable future for the sector, the EU should invest in training programs aimed at developing the next generation of mining professionals. This is especially critical given the current shortages of expertise, a consequence of the mining sector's decline in Europe.

Lastly, competing demand needs may undermine European coordinated policy towards minerals. Indeed, the EU is witnessing the upheaval of conflicting priorities with growing tension between climate and defence goals. To manage and coordinate future supply, a clear governance framework both at the European and national level is a *conditio sine qua non*. The Critical Raw Materials Board established by the Act is certainly a positive step.

At the international level, the EU is facing growing challenges – starting from its traditional ally, the United States. Although there are strong arguments for deeper transatlantic cooperation on minerals, including within the OECD framework, significant differences and frictions between the United States and the EU are increasingly apparent. Mineral resources have become a source of political tension across the Atlantic, particularly considering renewed US interests in unconventional solutions, like seizing Greenland by a combination of political pressure and economic coercion and incentives.[58] These divergent approaches undermine implementation of coordinated initiatives, like the MSP and the idea of a CRM buyers' club.

Despite current disagreements as well as different economic and political conditions, the EU and United States share many vulnerabilities and priorities. Therefore, joint initiatives, including joint security standards, remain valid and desirable as way to channel investments and support secure supplies. Existing platforms like the Transatlantic Trade and Technology Council (TTC) can help overcome disagreements and set common standards in the mineral sector. The EU should also frame and improve communication in engaging Washington by identifying joint strategic projects for multiple sectors, namely digital, defence, military and energy.

It is also important to prevent the deterioration of relations that could undermine key joint projects and initiatives, such as the development of the Lobito Corridor. This railway and economic corridor linking Zambia, the DRC and Angola is the

[57] Arthur Neslen, "Activist Opposed to Rio Tinto Lithium Mine Receives Anonymous Death Threats", in *The Guardian*, 22 August 2024, https://www.theguardian.com/p/xvaec3.

[58] Emily J. Holland, Joshua Busby and Morgan Bazilian, "Greenland's Minerals Won't Secure the U.S. Supply Chain", in *Energy World Blog*, 26 March 2025, https://nationalinterest.org/blog/energy-world/greenlands-minerals-wont-secure-the-u-s-supply-chain.

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first strategic project under the G7 Partnership for Global Infrastructure and Investment (PGII) and it was announced in a US-EU joint statement in May 2023.[59] The PGII was created to counter Chinese infrastructure investments under the Belt and Road Initiative.

Lastly, the EU needs to revise its raw material diplomacy as strategic partnerships have yet to bear meaningful results. Lack of coordination within the EU and poor implementation have resulted in growing frustration in partner countries.[60] Furthermore, the EU should consider new tools to achieve robust results. Indeed, using exclusively its regulatory power, such as the Environmental, Social and Governance (ESG) and circularity standards, may not lead substantial and positive results for energy security. In re-imaging its diplomacy and partnerships, the EU needs to consider that traditional trade measures, such as reduction of tariffs, provide very limited benefits as around 90 per cent of CRMs imports are already exempt from tariffs.[61]

At the same time, the EU should carefully consider potential challenges of common and shared approach with like-minded and importing countries; for instance, a buyers' club. This approach does face several issues in terms of governance, economic incentives and just transition.[62] Regarding the just transition dimension, the goal of a buyers' club would be to lower mineral prices (as opposite to sellers' club like OPEC). This could significantly harm emerging economies that rely on extractive industries.[63] Acknowledging also the needs of many of mineral-rich countries is essential to design a more credible CRM diplomacy. Nonetheless, joint demand mechanisms and frameworks among importing countries could send the economic signal to sign off-take agreements. These joint initiatives should marshal investments also in midstream and downstream activities abroad.[64] Besides the US, the EU should also work closely with other OECD countries that have clean industrial targets and industries.

[59] European Commission DG for International Partnerships website: *Connecting the Democratic Republic of the Congo, Zambia and Angola to global Markets through the Lobito Corridor*, https://international-partnerships.ec.europa.eu/node/2801_en.

[60] Poorva Karkare, "The EU's Partnerships around Critical Raw Materials: Do Its Ambitions Match Reality?", in *ECDPM Commentaries*, 26 March 2025, https://ecdpm.org/work/eus-partnerships-around-critical-raw-materials-do-its-ambitions-match-reality.

[61] Francesco Findeisen, "The Club Approach: Towards Successful EU Critical Raw Materials Diplomacy", in *Jacques Delors Centre Policy Briefs*, 31 October 2023, https://www.delorscentre.eu/en/publications/critical-raw-materials-club.

[62] Cullen S. Hendrix, "Why the Proposed Brussels Buyers Club to Procure Critical Minerals Is a Bad Idea", in *PIIE Policy Briefs*, No. 23-6 (May 2023), https://www.piie.com/node/16362.

[63] Ibid.

[64] Francesco Findeisen, "The Club Approach", cit.

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Conclusions and policy recommendations

Current market conditions and fundamentals provide enough minerals to global markets. However, growing geopolitical competition and more assertive trade and foreign policy by great powers have created enough political signal for re-evaluating the sustainability of current value chains. This political signal has already generated the increase of global minerals reserves and the addition of new players to the minerals industry. However, geographical concentration in China, especially in the mid and downstream, will be particularly difficult to change.

Market concentration and expected demand growth call on importing countries to pursue de-risking and diversification strategies. In this effort, the EU has adapted its framework to deal with its high import dependence. To achieve any meaningful results, the EU needs to address issues related to funding. As of today, the EU has not provided any new meaningful financial instrument aimed at building both local and international minerals projects. This should be part of the upcoming negotiations for the seven-year budget for 2028-2035, the multiannual financial framework (MFF). Furthermore, it should consider ensuring financial support not only for the capital investments (CapEx), but also for operating costs (OpEx) of strategic mineral projects. The EU needs to adapt its taxonomy and allow financial institutions to invest in all segments of CRMs supply chains also abroad.

Although direct investment is essential, the EU can overcome some financial constraints through the use of market-based mechanism, such as contracts for difference (CfD) and cap-and-floor models to support offtake and stabilise costs. Furthermore, coordinated procurement mechanisms will ensure demand security which is essential for investments in mineral-rich countries. These mechanisms will require better governance coordination both among and within EU institutions and member states.

Cooperation is crucial as independence is impossible. Having similar concerns, there are strong arguments for joining forces with other like-minded countries, including the US despite recent tensions. For these countries, it is crucial to work proactively with mineral-rich countries in a collaborative way. By doing so, the EU and its partners could exploit existing opportunities in key areas, like Africa. Particularly, Italy has the opportunity to shape future EU-Africa relations by integrating CRMs into its Mattei Plan. Although the country has some mineral resources, it will benefit of a more coordinated mineral diplomacy.

Updated 17 June 2025

List of acronyms

CapEx	Capital expenditure
CfD	Contracts for Difference
CRM	Critical raw material
DRC	Democratic Republic of the Congo
ESG	Environmental, Social and Governance
EU	European Union
EV	Electric vehicle
FDI	Foreign Direct Investment
GCC	Gulf Cooperation Council
HREE	Heavy Rare Earth Element
IEA	International Energy Agency
JOGMEC	Japan Organisation for Metals and Energy Security
LREE	Light Rare Earth Element
MFF	Multiannual financial framework
MoU	Memorandum of understanding
MSP	Mineral Security Partnership
OECD	Organisation for Economic Cooperation and Development
OPEC	Organisation of Petroleum Exporting Countries
OpEx	Operating expense
PGII	Partnership for Global Infrastructure and Investment
REE	Rare earths element
SRM	Strategic raw material
TTC	Trade and Technology Council
US	United States
WTO	World Trade Organisation

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Reality Check: The Regulatory Dimension of the EU De-risking Strategy for Critical Raw Materials and Semiconductors

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ABSTRACT

As global supply chains are exposed to mounting geopolitical shocks, the European Union is recalibrating its economic security strategy to reduce strategic dependencies and enhance indigenous industrial capacity. Two sectors stand at the heart of this effort: critical raw materials (CRMs) and semiconductors. Regulatory responses at the EU level include new benchmarks for extraction, processing, and recycling of CRMs, as well as efforts to bolster semiconductor production capacity through targeted funding and investment incentives. However, implementation gaps, internal fragmentation, and insufficient external coordination continue to hinder progress. Member states like Italy are taking steps to align national frameworks with EU objectives, focusing on CRM recycling and mature chip manufacturing. Strengthening partnerships with reliable third countries and fostering cross-sectoral policy coherence will be essential to secure Europe's strategic autonomy at a time of increased economic securitisation.

Critical raw materials | Semiconductors | European Union | Italy

keywords

Reality Check: The Regulatory Dimension of the EU De-risking Strategy for Critical Raw Materials and Semiconductors

by Francesca Maremonti*

Introduction

In her 2011 book, Sheila Ronis questioned the role of nations' economic security strategies at a time when "borders [were] less important than ever".[1] Since then, much has changed. Borders have increasingly been heightened and thickened, with protectionist drives guiding governments over the years, form the United States to Argentina, to several countries in the European Union. Economic security, far from its long-gone state of "neglected dimension", has gradually gained a central position in the agenda of administrations across the world. Japan was first, building the pillars of its economic security strategy since the early 2010s. Later, the United Stated launched its ambitions project of decoupling from China.

The EU followed suit. The geo-economic shocks of the recent years – including the cumulative impacts of the Covid-19 pandemic, the Russian invasion of Ukraine and the consequent energy crisis, the Taiwanese chip crunch and the semiconductor shortage – have prompted the Union to define an approach of its own towards economic security. Those shocks highlighted the risks associated with a troubling concentration of supply chains in East Asia and with the EU's dependencies on one or a handful of suppliers in strategic sectors. During the days of "borders-less important than ever", the EU benefitted from decades of globalisation, assuming stable geopolitical alliances and secure supply chains. However, economic cooperation is giving way to securitisation.

[1] Sheila R. Ronis (ed.), *Economic Security. Neglected Dimension of National Security?*, Washington, National Defense University Press, 2011, p. viii, https://apps.dtic.mil/sti/citations/ADA585192.

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When talking about dependencies, some distinctions ought to be made. Traditional dependence refers to an economy's inability to function without a specific resource. Russian fossil fuels – accounting for about half of the EU's gas imports before the invasion of Ukraine[2] and constituting a quarter of Europe's total energy imports[3] – fit this definition. The abrupt cut-off of Russian supplies posed an existential challenge for industries and households alike across the EU. It could be tempting to draw a comparison between this scenario and the EU's current dependencies on China for critical raw materials (CRMs)[4] – especially rare earth elements (REEs)[5] – and on strategic technologies underpinning its green and digital transition, such as semiconductors. However, the reality is more nuanced.

Europe's dependency on Chinese technologies has increased over the years, and in 2022, 38 per cent of the EU's high-tech imports from non-EU countries came from China.[6] Additionally, China currently provides 100 per cent of the EU's supply of heavy REEs.[7] Nonetheless, the greater risk faced by the EU is not an abrupt cessation of Chinese supply of processed CRMs. Rather, it is protracted series of disruptions to supply chains, which has been commonly referred to as "death by a thousand cuts". These minor shocks can materialise in the form of China imposing sporadic, targeted export restrictions, creating market volatility and disrupting the architecture of global supply chains. Similarly, the Trump's administration strategy and the looming over potential introduction of tariffs strategic sectors could heavily disrupt the configuration of global supply and production hubs.

To survive a potential "death by a thousand cuts", the EU has laid out an Economic Security Strategy, announced in June 2023, signalling growing awareness over the risks posed by geopolitical tensions, technological transformations and the weaponisation of economic dependencies.[8] The Economic Security Strategy is

[2] Ugnė Keliauskaitė, Simone Tagliapietra and Georg Zachmann, "Europe Urgently Needs a Common Strategy on Russian Gas", in *Bruegel Analysis*, 2 April 2025, https://www.bruegel.org/node/10783.

[3] Servet Yanatma, "Europe's 'Energy War' in Data: How Have EU Imports Changed since Russia's Invasion of Ukraine?", in *Euronews*, 24 February 2023, https://www.euronews.com/green/2023/02/24/europes-energy-war-in-data-how-have-eu-imports-changed-since-russias-invasion-of-ukraine.

[4] "CRMs combine raw materials of high importance to the EU economy and of high risk associated with their supply." See European Commission DG for Internal Market website: *Critical Raw Materials*, https://single-market-economy.ec.europa.eu/node/279_en.

[5] REEs "are a group of 17 elements, including the 15 elements of the lanthanide series on the periodic table of elements together with the transition metals scandium and yttrium". See Natural Resources Canada website: *Rare Earth Elements Facts*, last modified on 20 December 2024, https://natural-resources.canada.ca/node/20522. Their magnetic, electrical and optical properties make them vital components in various technologies, including electronics, energy and medical applications.

[6] Eurostat, *EU Trade in High-Tech Products up in 2022*, 10 May 2023, https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20230510-2.

[7] Council of the EU, "An EU Critical Raw Materials Act for the Future of EU Supply Chains", in *Infographics/Explaines*, last modified on 21 March 2025, https://www.consilium.europa.eu/en/infographics/critical-raw-materials.

[8] European Commission, *European Economic Security Strategy* (JOIN/2023/20), 20 June 2023, https://eur-lex.europa.eu/legal-content/en/TXT/?uri=celex:52023JC0020.

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built on three key pillars – the so-called "Three Ps": promote, protect and partner. The Three Ps provide the structure for actionable risk assessments in four critical risk areas: resilience of supply chains; security of critical infrastructure; technology security; economic coercion or the weaponisation of dependencies.

The EU paired its formally "country-agnostic" Economic Security Strategy with its De-risking Strategy, introduced by European Commission President Ursula von der Leyen in March 2023, stressing the importance of reducing overreliance on China for critical materials crucial for the green and digital transition.[9] Under this strategic framework, many EU member states are at work to strengthen their nationals economic security strategies and design policy measures to reduce overconcentration of supply in strategic sectors, while boosting indigenous industrial capacity.

This paper focuses on two strategic sectors: CRMs and semiconductors, given their relevance for the EU's strategic autonomy ambitions. It provides an analysis of the regulatory efforts undergone by the EU and by Italy to design strategies to de-risk and build more resilient supply chains. The two following sections will be dedicated respectively to CRMs and semiconductors – firstly, looking at the main risks and vulnerabilities of the respective supply chains and, secondly, at policy responses at the EU and Italian level, concluding with policy recommendations.

1. Critical raw materials

Critical raw materials have shifted from economic commodities to geopolitical assets. Used for a plethora of applications – from magnets to semiconductors and clean technologies – CRMs have become instrumental for the green and digital transition. The EU and its member states, including Italy, are grappling with a number of risks associated with CRM supply chains, trying to design measures to increase resilience and promote strategic autonomy.

1.1 CRMs: Challenges and risks

From an EU perspective, the greater challenge involving CRMs in the upcoming years is an exponential rise of demand, mostly driven by a record employment of green technologies, like solar panels and batteries.[10]

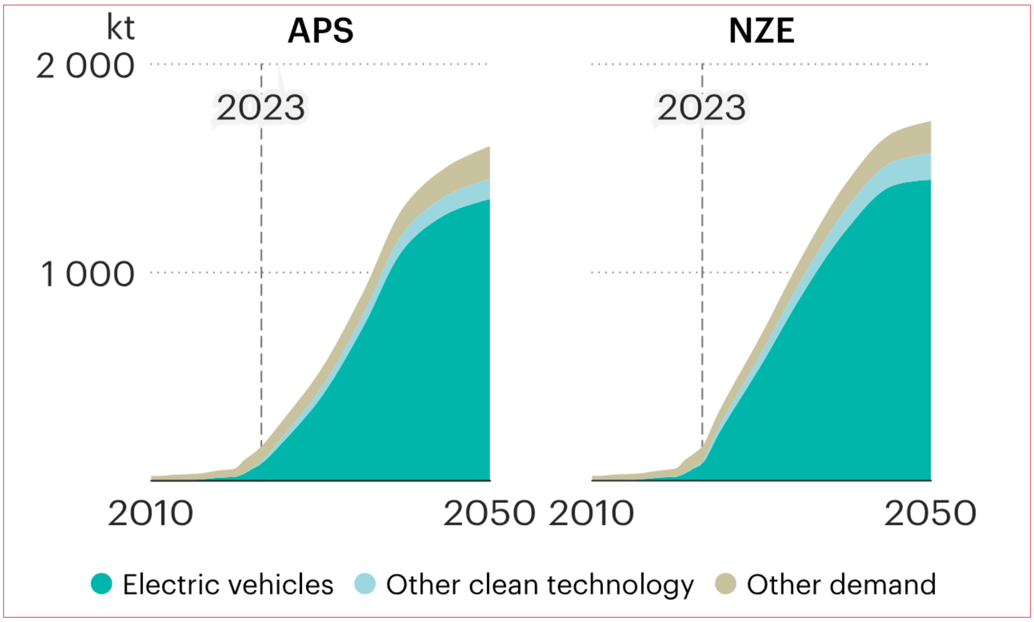
Over the next decades, demand is projected to grow further under the EU's ambitious goals of carbon neutrality by 2050, outlined in the European Green

[9] European Commission, *Speech by President von der Leyen on EU-China Relations to the Mercator Institute for China Studies and the European Policy Centre*, 30 March 2023, https://ec.europa.eu/commission/presscorner/detail/en/speech_23_2063.

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

Deal.[11] Mineral demand for green technology is expected to grow between 400 and 600 per cent by 2040.[12] Demand for lithium – a mineral instrumental to produce lithium-ion batteries (among other applications), the most widespread type of batteries used for electric vehicles (EVs) – tripled in the span of five years, between 2017 and 2022.[13] This trend is not likely to reverse (Figure 1).

Figure 1 | Demand outlook for lithium



Note: APS: Announced Pledges Scenario; NZE: Net Zero Emissions by 2050.
Source: International Energy Agency (IEA), *Global Critical Minerals Outlook 2024*, May 2024, p. 125, https://www.iea.org/reports/global-critical-minerals-outlook-2024.

Without secure access to CRMs supply, Europe's green transition, digital transformation and technological sovereignty are at risk. To face such a challenge, the EU needs to tackle a number of risks associated with CRM supply chains. Firstly, although mineral reserves are widespread across the globe, production is concentrated in a handful of countries, such as China, Australia, Chile. The European CRM value chain – exploration, extraction, refining, processing and recycling – is fragile at every segment. China, on the contrary, holds a very dominant position along the CRM supply chain, as a result of long-standing state policies to move ahead of its international competitors. Though China does not hold a near-monopoly on CRM reserves, it is the world's largest importer of raw

[11] European Commission DG for Climate Action website: *2050 Long-term Strategy*, https://climate.ec.europa.eu/node/56_en.

[12] Mario Draghi, *The Future of European Competitiveness. Part B*, September 2024, p. 45, https://commission.europa.eu/node/32880_en.

[13] IEA, *Global EV Outlook 2023*, April 2023, p. 57, https://www.iea.org/reports/global-ev-outlook-2023.

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materials,[14] to then cements its leading position in the refining and processing segments.[15]

As CRMs become a market shaping tool, countries like China can exploit their heft and apply market restriction to stir supply chains or to suppress the competitors' industrial growth. This scenario materialised in 2020 when – as Europe was pushing to expand its battery component production – Swedish battery leader Northvolt was subjected to a Chinese export ban on graphite – a mineral needed for anode production.[16] Securing these exports could have strengthened Europe's manufacturing capacity. Instead, by 2023, China's Putailai announced a 1.3 billion US dollars investment to build Europe's largest anode manufacturing plant in Sweden, with Northvolt – which eventually filed for bankruptcy in 2024 – set to become its customer.[17]

Another scenario looming over Europe involves the weaponisation of market restrictions. In response to tariff hikes on Chinese imports introduced by US President Donald Trump, China's Ministry of Commerce announced on 4 April 2025 new export controls targeting key REEs. The measure affects seven specific REEs[18] – essential in sectors such as defence, energy and automotive manufacturing – and the derived permanent magnets.[19] The regulatory framework required companies to obtain special export licenses to ship these materials and related magnet technologies abroad; with slower exports directly impacting the EU and US automotive sector, particularly that of EVs.[20]

This move underscores the strategic value of REEs, with market dynamics poised to shift quickly if export disruptions occur or if delays in approving shipments to certain regions materialise. Stockpiling for CRMs could cushion the risk of weaponisation towards single countries and mitigate the risks of supply shocks.[21] However, unlike for fossil fuels, the EU lacks an inventory stock of CRMs to this

[14] International Trade Centre, "Trade in Critical Minerals by Processing Leve", in *Trade Briefs Spotlights*, September 2023, https://tradebriefs.intracen.org/2023/9/spotlight.

[15] Zhou Weihuan, "Why China's Critical Mineral Strategy Goes beyond Geopolitics", in *World Economic Forum Opinions*, 19 November 2024, https://www.weforum.org/stories/2024/11/china-critical-mineral-strategy-beyond-geopolitics.

[16] Economist, "Why Is China Blocking Graphite Exports to Sweden?", in *The Economist*, 22 June 2023, https://www.economist.com/business/2023/06/22/why-is-china-blocking-graphite-exports-to-sweden.

[17] Richard Milne, Edward White and Gloria Li, "Chinese Group Putailai to Build Europe's Largest Anode Factory in Sweden", in *Financial Times*, 4 May 2023, https://www.ft.com/content/80d34254-3e12-4fa7-8f02-fdceb1c2fa2e.

[18] Samarium, gadolinium, terbium, dysprosium, lutetium, scandium and yttrium.

[19] Gracelin Baskaran and Meredith Schwartz, "The Consequences of China's New Rare Earths Export Restrictions", in *CSIS Critical Questions*, 14 April 2025, https://www.csis.org/node/115778.

[20] Edward White, Ryan McMorrow and Harry Dempsey, "Global Supply Chains Threatened by Lack of Chinese Rare Earths", in *Financial Times*, 18 May 2025, https://t.co/RMSVm8XyZM.

[21] Ivano di Carlo (ed.), "EU–China Relations at a Crossroads, Vol. III: Business Unusual", in *EPC Compendium*, 30 June 2024, https://www.epc.eu/publication/EUChina-relations-at-a-crossroads-Vol-III-Business-unusual-5c8974.

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day. The geographical concentration of supply also introduces a higher risk of collusion among countries holding a strong position along the CRM supply chain. Countries could potentially coordinate to align to disrupt supply, raise prices or impose coordinated restrictions, as it happened with the Democratic Republic of Congo (DRC) and Indonesia for cobalt, from early 2025. This scenario, detrimental for highly dependent importers, such as the EU, is aggravated by the EU's reliance on countries with low governance rankings.[22]

All of these risks contribute to the price volatility. Extreme fluctuations risk freezing capital flow along the entire value chain. Going back to the case of lithium, it appears clear how severe this can get: prices skyrocketed twelvefold in two years, then crashed by over 80 per cent.[23] Persistent volatility continues to deter investment decisions and could, in turn, reinforce market concentration and minimise the effort to diversify. In fact, the market share of top producers of CRMs worldwide has remained the same since 2022, and even cemented in sectors like nickel.[24]

1.2 EU responses

First steps

The EU has introduced a rich tapestry of measures and initiatives to translate its de-risking strategy into tangible actions. Building on the 2008 European Raw Material Initiative[25] – which provides a framework to establish an integrated strategy to face the challenges related to access to CRMs – in 2020 the Commission presented an Action Plan on Critical Raw Materials to reduce Europe's dependency on third countries and diversify supply.[26]

Over the years, the Commission has elaborated a list of raw materials critical for the EU's economy. The first list, released in 2011 with fourteen elements, has now expanded to 34 CRMs, and was lastly updated in 2023.[27] The list distinguishes between "critical" and "strategic" raw materials (SRMs).[28] "Criticality" is based on the

[22] Understood as political stability, government effectiveness, rule of law, control of corruption, and voice and accountability, indicating higher potential risks of supply disruptions.

[23] Ahmed Mehdi, "Lithium Price Volatility: Where Next for the Market?", in *OIES Energy Insights*, No. 145 (February 2024), https://www.oxfordenergy.org/?p=47018.

[24] Mario Draghi, *The Future of European Competitiveness. Part B*, cit., p. 46.

[25] IEA website: *European Raw Materials Initiative*, last updated on 12 December 2023, https://www.iea.org/policies/15696-european-raw-materials-initiative.

[26] European Commission, *Commission Announces Actions to Make Europe's Raw Materials Supply More Secure and Sustainable*, 3 September 2020, https://ec.europa.eu/commission/presscorner/detail/en/ip_20_1542.

[27] European Commission DG for Internal Market website: *Critical Raw Materials*, https://single-market-economy.ec.europa.eu/node/279_en.

[28] European Commission's Raw Materials Information System (RMIS) website: *Critical and Strategic Materials*, https://rmis.jrc.ec.europa.eu/eu-critical-raw-materials.

economic relevance of the raw material, its supply risk, potential for substitution, import reliance and the so-called Herfindahl-Hirschman Index (HHI), a measure to calculate the supply risk and production concentration.[29] SRMs are determined by their relevance to the green and digital transition, as well as for defence and aerospace purposes.[30]

In 2020, the European Raw Materials Alliance was established, bringing together the most relevant stakeholders involved along the CRMs value chain, like the private sector, trade unions, research and technology organisations.[31] Its workstream is channelled into two main objectives: value chain-specific consultation processes and investment channel for raw materials projects.[32] Despite the commitment to valuable initiatives, such as launching a Raw Materials Investment Platform (RMIP), results are yet to materialise and the impact of the Alliance to this day remains very limited.

The Critical Raw Material Act

Building on the pillars of the EU's CRMs strategy laid out over the past decade, the EU cemented its de-risking regulatory effort with the release of the Critical Raw Material Act (CRMA), in April 2024. The CRMA was designed alongside the Commission's Net Zero Industry Act, which introduces measures to strengthen Europe's supply diversification and scale up manufacturing of carbon-neutral technologies for clean energy supply chains.[33]

The CRMA sets concrete benchmarks for 2030. The EU intends to extract at least 10 per cent of its annual consumption of strategic raw materials domestically, process at least 40 per cent within its borders, and recycle at least 25 per cent of that total.[34] To support these targets, the Act introduces measures to streamline permitting processes for strategic projects, cutting approval times to a maximum of 24 months for extraction projects and 12 months for processing or recycling initiatives. Sustainability and circularity are key objectives of the Act, encouraging material recovery from waste and introducing certification schemes to ensure adherence to environmental and social standards. A Raw Materials Academy is being launched to build a skilled workforce for the sector.

[29] Gian Andrea Blengini et al., *Study on the EU's List of Critical Raw Materials (2020). Final Report*, Luxembourg, Publications Office of the EU, 2020, p. 50, https://doi.org/10.2873/11619.

[30] James Hackett et al., "Critical Raw Materials and European Defence", in *IISS Research Papers*, March 2025, https://www.iiss.org/research-paper/2025/03/critical-raw-materials-and-european-defence.

[31] Ibid.

[32] European Raw Material Alliance (ERMA) website: *Workstreams*, https://erma.eu/workstreams.

[33] European Commission DG for Internal Market website: *The Net-Zero Industry Act: Making the EU the Home of Clean Technologies Manufacturing and Green Jobs*, https://single-market-economy.ec.europa.eu/node/2089_en.

[34] European Commission DG for Internal Market website: *Critical Raw Materials Act*, https://single-market-economy.ec.europa.eu/node/2053_en.

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Implementation of the CRMA is already underway at the national level. France, for example, has launched a 53 million euro resource mapping initiative and allocated 500 million euros under its France 2030 plan to boost domestic production and recycling.[35] Germany has created a Raw Materials Fund worth around 1 billion euros to support projects that enhance access to CRMs and reduce dependence on Chinese imports.[36] Spain is focusing on identifying and reactivating domestic sources, including lithium and rare earth elements,[37] while Sweden is leveraging its mining sector to develop rare earth supply for high-tech industries.

Under the CRMA, the Commission, in March 2025, approved 47 strategic projects across thirteen member states.[38] These projects are intended to boost the EU's capacity to extract, process, and recycle fourteen priority materials, all essential to the energy transition and economic security. The CRMA supports these efforts by ensuring faster regulatory approval and unlocking financial support from both public and private sources.

The cooperation dimension

A time of rising protective measures and growing protectionism across administrations worldwide begs the question on the difference between inward-looking protectionism and economic security strategies. One answer, and one stark difference, can be found in the cooperation dimension of economic security.[39] International cooperation remains a critical pillar of the CRMA, and the charted way to push supply diversification further.

The EU plans to strengthen partnerships with reliable third countries to diversify its raw material imports and avoid overdependence on any single nation, aiming for no more than 65 per cent of the EU's annual consumption of any strategic raw material relying from one country.[40] Over the years, the EU has secured a number of memorandum of understanding (MoUs) with mineral-rich countries, such as Canada (2021), Namibia (2022), Argentina (2023) and Chile (2023).[41] However,

[35] BRGM, A New Programme to Identify French Mineral Resources, 13 February 2025, https://www.brgm.fr/en/node/1796.

[36] Kamil Kowalcze, "Germany Invests €1 Billion to Counter China on Raw Materials", in *Bloomberg*, 2 February 2024, https://www.bloomberg.com/news/articles/2024-02-02/germany-to-channel-1-billion-to-critical-raw-material-needs.

[37] SOS Suído-Seixo, *Lithium Mining in South Galicia, Spain. Critical Factsheets on Mining Projects*, December 2024, https://eurmc.org/?p=2873.

[38] European Commission, *Commission Decision (EU) 2025/840 of 25 March 2025 Recognising Certain Critical Raw Material Projects as Strategic Projects...*, http://data.europa.eu/eli/dec/2025/840/oj.

[39] Francesca Ghiretti, "Economic Security or Protectionism", in *Chinese Investments and the Economic Security Turn in Europe*, Bristol, Bristol University Press, 2025, p. 52-65.

[40] European Commission DG for Internal Market website: *Critical Raw Materials Act*, https://single-market-economy.ec.europa.eu/node/2053_en.

[41] Bryan Bille, *Increasing Lithium Supply Security for Europe's Growing Battery Industry: Recommendations for a Resilient Supply Chain*, The Hague, The Hague Centre for Strategic Studies,

many of these mining projects are stuck at the MoU level. In summer 2024, for instance, the EU sealed an MoU with Serbia to start mining lithium and "enhance the development of value chains for raw materials, batteries and EVs".[42] This initiative has met the strong backlash from Serbian society, which has pushed back against the environmental impact of the mining facility. This case exposes the complexity of balancing climate as well as social sustainability into the EU's de-risking equation – still unsolved.

The Commission has also intertwined its de-risking ambitions to the Global Gateway, the EU's strategy to promote infrastructural investments in the digital, energy and transport sectors – ostensibly the counteract China's Belt and Road Initiative.[43] Under the Global Gateway umbrella, some of the MoUs signed by the EU have been upgraded to Strategic Partnerships, thus securing imports of CRMs, as for the case of the agreement signed with the DRC in December 2024[44] or the case of Kazakhstan in March 2025.[45]

However, the mining industry model has evolved over the years. Several countries with abundant mineral reserves are aiming to spur higher-value mineral industry, scaling up from mining to more profitable businesses, such as refining and processing facilities.[46] China has been able to meet those ambitions, putting forward investments packages that link mining operations with energy and infrastructural development. The rapid results and visible economic gains have been welcomed favourably by many administrations of mineral-rich African countries, like in the DRC. China's footprint in Africa today outcompetes the EU approach to cooperation. In fact, EU investments projects cut across different Directorates-General (DGs), such as DG INTPA (international partnerships), DG GROW (internal market) and DG Trade (trade relations).[47] The complex articulation of the EU's internal competences often reflects into a fragmentation of the EU's external impact, hindering the overall scope of European Raw Material Diplomacy (RMD).[48]

January 2024, https://hcss.nl/?p=62768.

[42] European Commission DG for Neighbourhood, *EU and Serbia Sign Strategic Partnership on Sustainable Raw Materials, Battery Value Chains and Electric Vehicles*, 19 July 2024, https://enlargement.ec.europa.eu/node/4991_en.

[43] European Commission website: *Global Gateway*, https://commission.europa.eu/node/5445_en.

[44] European Commission DG for International Partnerships, *Global Gateway: EU Endorses Roadmap for Strategic Partnership on Raw Materials with the Democratic Republic of Congo*, 11 December 2024, https://international-partnerships.ec.europa.eu/node/3648_en.

[45] Assel Satubaldina, "EU Deepens Global Gateway Partnership with Kazakhstan with Deals in Critical Raw Materials and Transport", in *The Astana Time*, 13 March 2025, https://astanatimes.com/?p=98317.

[46] Indonesia has successfully pioneered this model, by introducing export bans on nickel exports, thus attracting Chinese investments to establish processing facilities in the countries through joint ventures with local companies.

[47] Poorva Karkare, "The EU's Partnerships Around Critical Raw Materials: Do Its Ambitions Match Reality?", in *ECDPM Commentaries*, 26 March 2025, https://ecdpm.org/work/eus-partnerships-around-critical-raw-materials-do-its-ambitions-match-reality.

[48] European Commission DG for Internal Market website: *Raw Materials Diplomacy*, https://single-market-economy.ec.europa.eu/node/481_en.

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Overall, the EU's strategy for securing CRMs has indeed evolved over the years, flagging mounting concern over potential supply disruptions, resulting in foresight studies issued by the EU Commission, strategic communications, parliamentary resolutions. However, these measures and the CRMA's goals have often been outpaced by geopolitical shocks, got stuck between the policy and the investment dimension, or are yet to materialise and be evaluated.

1.3 Italy's responses

Domestic level

Italy, like several other EU countries, has scaled up its effort to de-risk the national CRM sector, following the path charted by the EU. In June 2024, the Italian government overhauled its mining regulatory framework, which had previously been governed by the Royal Decree dating back to 1927. Italy's regulatory updates strongly align with the EU's CRMA, to reduce reliance on imports by tapping into domestic resources, strengthening indigenous mineral industry and diversifying imports.[49] Key measures include a register for supply chain bottlenecks and the streamlining of the permitting process for mining concessions, with licenses required to be issued within eighteen months. The new decree also allows for the reopening of abandoned mines in regions like the Alps, Tuscany and Sardinia.

Additionally, several initiatives have been launched at the national level to increase CRM supply chains resilience. Among these, in collaboration with research institutions such the Italian Institute for Environmental Protection and Research (ISPRA),[50] the national institute for environmental research and protection, the government has launched a National Exploration Programme to map national mineral resources.[51] One key initiative, ISPRA-GEMMA, has identified domestic CRM resources, including Europe's largest fluorite mine located in Silius, Sardinia. To spur investments, a government-backed fund, the National Fund for Made in Italy,[52] has been announced in February 2024. The initial capital allocated to the Fund, 1 billion euros, is aimed at investments in strategic technological sectors, as well as investments along every segment of the CRM value chain.[53] Additionally,

[49] Italian Parliament Research Department, "Disposizioni urgenti sulle materie prime critiche di interesse strategico", in *Dossier*, No. 305 (1 July 2025), https://documenti.camera.it/leg19/dossier/pdf/D24084.pdf.

[50] Istituto superiore per la protezione e la ricerca ambientale.

[51] ISPRA website: *Database Quarries and Mines Geological Service of Italy – GEMMA*, https://www.isprambiente.gov.it/en/projects/soil-and-territory/mines-and-quarries/remi-project-national-network-of-italian-mining-parks-and-museums/the-data-bases/database-quarries-and-mines-geological-service-of-italy-gemma.

[52] Managed by Cassa Depositi e Prestiti and Invimit.

[53] Italian Government, *Fondo nazionale del Made in Italy – adottato il decreto attuativo, 6 March 2025*, https://www.programmagoverno.gov.it/it/notizie/fondo-nazionale-del-made-in-italy-adottato-il-decreto-attuativo.

the Italian Ministry of Environment and Energy Security (MASE), under the REpowerEU scheme, allocated 50 million euros from the National Recovery and Resilience Plan (PNRR, funded by the EU's post-pandemic recovery plan), to boost recycling of CRMs.[54]

International level

Among the EU Strategic Projects launched under the CRMA umbrella, four are hosted on Italian soil.[55] Two of these projects focus on recycling – of platinum group metals, copper and nickel – and two on recovery – of lithium for battery production and of rare earth elements for magnets.[56] While mining projects face a seven-to-ten-year lag time, recycling facilities can be operational in two to four years, representing a big market opportunity for Italy.

Moving beyond the European borders, Italy signed an MoU with Kazakhstan in 2023 – under the framework of the EU's strategic partnership – including a joint declaration on rare earths.[57] Additionally, Italy's effort to diversify and secure CRM supply chains has been inscribed into the Mattei Plan,[58] the national infrastructural and development project promoting cooperation with Africa.[59] However, Italy faces challenges similar to those the EU is confronted by, when it comes to establishing partnerships with resource-rich countries in Africa. In particular, engaging the countries along the so-called Lobito Corridor (Zambia, the DRC and Angola) has proven difficult. As those regions have already been the recipient of China's vast investments to spur local industry, Italy struggles positioning itself in this competitive environment. The first shipment of CRMs mined along the Lobito Corridor was shipped from Angola's port in spring 2025, headed to China.

Up until this day, Italy's CRM strategy, articulated in frameworks like the Royal Decree and the Mattei Plan, remains trapped between aspiration and operational delivery, as no strategic mining project has been launched at a national level nor through international partnerships. Securing CRM supply is not just instrumental for Italy's mineral industry, but it is pivotal for another strategic sphere which Italy aims to de-risk, namely the semiconductor sector.

[54] MASE website: *M7 – Investimento 8: Approvvigionamento sostenibile, circolare e sicuro di materie prime critiche*, last updated on 23 June 2025, https://www.mase.gov.it/portale/-/m7-investimento-8-approvvigionamento-sostenibile-circolare-e-sicuro-di-materie-prime-critiche-.

[55] European Commission, *Commission Decision (EU) 2025/840 of 25 March 2025*, cit.

[56] Alpha Project developed by Solvay Chimica Italia; LIFE-22-ENV- ITINSPIREE developed by Itelyum Regeneration SpA; Portovesme CRM Hub developed by Portovesme CRM Hub; RECOVER-IT developed by Circular Materials s.r.l.

[57] "Tajani in Kazakhstan: Joint Declaration on Rare Earths and Industrial Cooperation Signed in Astana", in *Agenzia Nova*, 6 September 2023, https://www.agenzianova.com/en/news/?p=241644.

[58] Named after the founder of Italy's energy giant Eni, Enrico Mattei.

[59] Italian Ministry of University and Research website: *Piano Mattei Ricerca e Alta Formazione*, https://www.mur.gov.it/it/node/3647.

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2. Semiconductors

2.1 The EU semiconductor ecosystem

The global semiconductor industry has become a frontline in strategic competition, one wherein Europe is struggling to keep up. Chips underpin every critical technology, from artificial intelligence (AI) to defence systems, and control over their production is rapidly becoming a core metric of geopolitical leverage. The semiconductor market structured on a small number of large players: the United States is leading in the chips design sector;[60] Taiwan, South Korea and China in chip manufacturing, and Japan and some EU member states in key materials and equipment – optics, chemistry and machinery.[61]

Europe's position in the global value chain is weak and shrinking. The EU accounts for less than 10 per cent of global semiconductor production[62] – down from 24 per cent in 2000. In contrast, the Asia Pacific region dominates production, with Taiwan's TSMC alone controlling over half the global foundry market.[63] The strategic implications of this dependency are increasingly evident. Semiconductor supply chains are already entangled in US-China tech rivalry and any disruption, particularly in the Taiwan Strait, would ripple across every European sector relying on advanced electronics, from automotive to defence.

Europe's strengths are not insignificant, but they are lopsided. The Eu's semiconductor industrial base lacks front-end production of advanced chips. Dutch ASML, and other European firms, are involved in that segment of the chip value chain, providing equipment – extreme ultraviolet (EUV) photo machines, indispensable to produce chips below 7nm. However, the EU lags behind even on mature chip production, a sector where the bloc risks developing sticky dependence from China.[64] IMEC, headquartered in Belgium, is a global leader in pre-competitive research and development (R&D) and collaborates with leading US and Asian firms, as for the pilot testing launched in April 2025 in collaboration with Japanese semiconductor manufacturer Rapidus.[65] But neither equipment nor

[60] Aurelio Insisa, "Italy's De-Risking Efforts in the Semiconductor Industry, the European Chips Act, and Sino-American Geo-Economic Competition", in *IAI Papers*, No. 25|05 (June 2025), https://www.iai.it/en/node/20190.

[61] Mario Draghi, *The Future of European Competitiveness. Part B*, cit.

[62] Kjeld van Wieringen, "Global Semiconductor Trends and the Future of EU Chip Capabilities", in *ESPAS Ideas Papers*, 2022, p. 3, https://www.espas.eu/files/Global-Semiconductor-Trends-and-the-Future-of-EU-Chip-Capabilities-2022.pdf.

[63] Economist, "Taiwan's Dominance of the Chip Industry Makes It More Important", in *The Economist*, 6 March 2023, https:// www.economist.com/special-report/2023/03/06/taiwans-dominance-of-the-chip-industry-makes-it-more-important.

[64] Tim Nicholas Rühlig, "Curbing China's Legacy Chip Clout. Reevaluating EU Strategy", in *EUISS Briefs*, 21/2024 (December 2024), p. 2, https://www.iss.europa.eu/node/3313.

[65] Atsuyoshi Koike, "Moving into Pilot Production for World-Leading 2nm Logic Chips", in *Rapidus website*, 1 April 2025, https://www.rapidus.inc/en/interview/it0001.

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R&D leadership can compensate for the EU's inability to build and scale domestic chip design and industrial capacity.

The sector of chip design or "fabless design" – namely creating the layout of chips, to be manufactured in foundries or "fabs", accounts for 50 per cent of value-added in the industry, is in fact a critical blind spot.[66] Europe has no equivalent to US giants like NVIDIA, Qualcomm or AMD, nor the ecosystem to support them. Without strengthening its design base, Europe will build fabs that rely on foreign intellectual property, mirroring the dependency trap of CRMs.

Additionally, the fragmented nature of European stock market makes it a fraction compared to the one in the United States. Compounding all this, Europe is set to face a severe labour and talent shortage in the upcoming years. The European semiconductor industry faces an estimated shortfall of 50,000 to 70,000 high-skilled workers by 2030.[67] Without a rapid upskilling strategy, Europe will lack the pillars for the very infrastructure it is trying to build.

2.2 EU's de-risking measures

Promotive measures

Following the chip shortages of the chip crunch of 2021 and the supply shocks of the Covid-19 pandemic, the EU Commission proposed the European Chips Act, which entered into force in September 2023.[68] Aiming to double Europe's global semiconductor market share to 20 per cent by 2030, the Act rests upon three pillars.[69] The first, the Chips for Europe Initiative promotes innovation through R&D and pilot lines, to take the industry "from lab to fab".[70] The second pillar aims at "Security of Supply", supporting national manufacturing initiatives through Important Projects of Common European Interest (IPCEIs). The last pillar, "Crisis Coordination Mechanism" looks at potential supply shocks and aims at developing early-warning mechanisms, such as the Semiconductor Alert System.[71]

The EU Chips Act mobilises 43 billion euros coming from public funding from the EU and member states (15 billion euros) as well as from private investment and IPCEIs. Despite this significant cash injection, the EU's funding levels remain significantly lower than its competitors'. The US government, under the

[66] Hideki Tomoshige and Bailey Crane, "RAI Explainer: Strategic Importance of Continued U.S. Leadership in Chip Design", in *CSIS Blogs*, 19 January 2024, https://www.csis.org/node/108957.

[67] Raphaël Beaujeu, Léo Saint-Martin and Cédric Lebon, *Skills Strategy 2024*, European Chips Skills Academy, November 2024, https://chipsacademy.eu/?p=1344.

[68] European Commission website: *European Chips Act*, https://commission.europa.eu/node/5524_en.

[69] Ibid.

[70] European Commission DG for Communications Networks website: *European Chips Act*, https://digital-strategy.ec.europa.eu/en/node/10695.

[71] Ibid.

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Chips and Science Act of 2022, has authorised a total of 182 billion US dollars in investments allocated to the semiconductor ecosystem. Part of this funding, 174 billion, is destined to R&D, education and workforce development,[72] while 53 billion of federal incentives are allocated to semiconductor manufacturing, with additional funding for the Department of Defense.[73] China, in 2022, pushing for semiconductor self-sufficiency, has unveiled a support package exceeding 1 trillion yuan (approximately 143 billion US dollars), to provide subsidies and tax incentives to domestic semiconductor firms.[74]

Additionally, the EU Chips Act does not address some of the weaknesses of the bloc's industrial capacity, with limited focus on cutting-edge manufacturing (advanced nodes). Several countries have taken action to ramp up their indigenous industries (see table below). However, progress remains fragmented, with limited synergy across member states.

Table 1 | Member states' de-risking measures for semiconductors

Country	Strategy or initiative	Year
Italy	Chips Fund (3.3 billion euros), national design centre (Chips-IT)	2022
Germany	20 billion euros investment plan, support to Intel and TSMC, ESMC project in Dresden	2022–23
France	Support for STMicroelectronics expansion, IPCEI involvement	2022
Spain	PERTE Chip Plan (12.25 billion euros), national semiconductor strategy	2022
Poland	Joined EU Chips Coalition, investments in R&D and talent pipeline	2023
Czech Republic	National Semiconductor Strategy (aims to triple capacity by 2029)	2024
Portugal	National Chips Strategy (focus on training and R&D)	2023
Finland	Chips Coalition member, strong focus on microelectronics R&D	2023
Austria	National initiatives to attract semiconductor investments, Coalition participation	2023
Belgium	No formal act, but strategic leadership via IMEC	–
Netherlands	Coalition proposal and industrial leadership via ASML	–

[72] David Young, John Gardner and Mallory Block, "The Future of the CHIPS and Science Act", in *CED Policy Backgrounders*, 13 March 2025, https://www.conference-board.org/research/ced-policy-backgrounders/the-future-of-the-CHIPS-and-Science-Act.

[73] Michelle Kurilla, "What Is the CHIPS Act?", in *CFR In Briefs*, 29 April 2024, https://www.cfr.org/node/252105.

[74] Julie Zhu, "Exclusive: China Readying $143 Billion Package for Its Chip Firms in Face of U.S. Curbs", in *Reuters*, 14 December 2022, https://www.reuters.com/technology/china-plans-over-143-bln-push-boost-domestic-chips-compete-with-us-sources-2022-12-13.

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In March 2025, industry groups ESIA and SEMI Europe – representing chipmakers and the broader industry respectively – have called for the Commission to elaborate a Chips Act 2.0, addressing previous shortcomings. Commissioner Henna Virkkunen – responsible for Tech Sovereignty, Security and Democracy – committed to approve a second version of the Chips Act by 2026.[75] To keep up with the challenges of an increasingly AI-driven economic and society, the EU launched its "AI continent action plan" in April 2025.[76] As Europe's AI industry is dependent on hardware produced largely by the US company Nvidia, as well as from imports of germanium and gallium from China, a Chips Act 2.0 could be designed in closer alignment with the newly released "AI continent action plan" and the EU's CRMs de-risking strategy.

Protective measures

In January 2024, the Commission proposed new initiatives to strengthen the bloc's economic security, through trade and financial tools.[77] Among these, a revision of inbound foreign direct investment (FDI) mechanisms has been launched. Semiconductor manufacturing has been identified as one of the most sensitive sectors for screening, with a total of 6.6 billion US dollars in capital invested in 2022, coming from the United States (41 per cent), the United Kingdom (7.4 per cent), Japan and China (both per cent).[78] For outbound investments, screening mechanisms are instrumental in monitoring transfers of sensitive technological know-how or production capabilities. In January 2025 the Commission published a Recommendation to review outbound investments screening mechanisms to scrutinise three critical sectors: semiconductors, AI and quantum technologies.[79] Member states will report to the Commission on their findings and risk assessment by summer 2025, to be approved by summer 2026.[80] This consultation should feed into a policy proposal for a EU regulatory framework for outbound FDIs, whose approval is likely to be still several years away, if ever to materialise.

On the trade side – similarly to CRMs – export controls have turned semiconductor firms from a market asset into pawns of geopolitical leverage. In October 2022,

[75] Jacob Wulff Wold, "Virkkunen Confirms a Chips Act 2.0 and Outlines AI Action Plan", in *Euractiv*, 26 March 2025, https://www.euractiv.com/?p=2230455.

[76] European Commission website: *Shaping Europe's Leadership in Artificial Intelligence with the AI Continent Action Plan*, https://commission.europa.eu/node/38607_en.

[77] European Commission, *Commission Proposes New Initiatives to Strengthen Economic Security*, 24 January 2024, https://ec.europa.eu/commission/presscorner/detail/en/ip_24_363.

[78] Hannah Ahamad Madatali, "Revision of the EU Foreign Direct Investment Screening Regulation", in *EPRS Briefings*, July 2024, https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2024)762844.

[79] European Commission, *Commission Calls on Member States to Review Outbound Investments and Assess Risks to Economic Security*, 15 January 2025, https://ec.europa.eu/commission/presscorner/detail/en/ip_25_261.

[80] European Parliament, *Legislative Train Schedule: Outbound Investment Screening*, as of 21 May 2025, https://www.europarl.europa.eu/legislative-train/theme-an-economy-that-works-for-people/file-outbound-investment-screening.

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the US Bureau of Industry and Security (BIS) introduced new export controls for advanced semiconductor manufacturing equipment technology to China, to gain competitive advantage over China's ascend of advanced semiconductor manufacturing.[81] After bilateral talks between the United States and the Dutch government, in January 2023 the Netherlands – home to ASML firm – introduced advanced semiconductor equipment export controls to China. Japan followed suit, restricting Nikon and Canon's exports of critical lithography equipment to China.[82] China did not retaliate directly, but introduced export bans on germanium and gallium later in 2023, exposing the intertwinement between de-risking the semiconductor and the CRM sector.

This episode shed light on two of the vulnerabilities of the EU approach towards protective measures. The first is represented by the uncoordinated postures of member states and the lack of integration of national measures at the EU level, as shown by the US-Dutch bilateral agreement on export controls. The second weak spot is the lack of coordination with other key players. Closer alignment with Japan, for instance, could have given greater leverage to EU-Japanese export controls or FDI screenings, to reduce overexposure to US geopolitical pressure and avoid getting entangled in the US-China tech competition.

2.3 Italy's de-risking measures

Italy's footprint in the European semiconductor ecosystem is growing, although not without challenges. In line with the EU regulatory framework, in August 2023 the Italian government introduced new measures to layout its chip national strategy, under the so-called Assets Decree,[83] approved in October 2023.[84] The most significant initiative at the Italian level is the launch of a national chip fund, which allocates 3.3 billion euros for investments in the semiconductor industry, spanned out between 2022 and 2030.[85] With these initiatives, Italy aims to spur industrial capacity, while attracting foreign capital, boost R&D and simplify the bureaucratic process for grant project approvals.

Italy's indigenous industry is indeed gaining momentum. Its strength relies on manufacturing of high-volume mature nodes (28nm, 40nm, 65nm) – critical for

[81] US Bureau of Industry and Security, *Commerce Implements New Export Controls on Advanced Computing and Semiconductor Manufacturing Items to the People's Republic of China (PRC)*, 7 October 2022, https://www.bis.doc.gov/index.php/component/docman/?task=doc_download&gid=3158.

[82] Victor De Decker and Patrick Grady, "Fortifying Europe's Semiconductor Ecosystem", in *Egmont Policy Briefs*, No. 344 (June 2024), https://www.egmontinstitute.be/?p=48338.

[83] Decree-Law No. 104 of 10 August 2023: *Disposizioni urgenti a tutela degli utenti, in materia di attività economiche e finanziarie e investimenti strategici*, https://www.normattiva.it/uri-res/N2Ls?urn:nir:stato:decreto.legge:2023-08-10;104.

[84] Italian Government, *Focus sul decreto-legge n. 104/2023 coordinato con la legge di conversione n. 136/2023 "Decreto Asset"*, 16 October 2023, https://www.programmagoverno.gov.it/it/notizie/focus-sul-decreto-legge-n-1042023-coordinato-con-la-legge-di-conversione-n-1362023-decreto-asset.

[85] Fondo nazionale per la microelettronica.

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automotive, defence and industrial applications. Sicily-based[86] STMicroelectronics – producing silicon carbide chips, essential for electric vehicles and renewables – has announced an investment plan to expand the manufacturing facility worth 5 billion euros, 2.1 of which coming from public funding.[87] In Novara, in the Piedmont region, a construction plan for an advanced packaging[88] facility has been sealed, bringing together foreign investments from the Singaporean firm Silicon Box and an investment package from EU funding worth 1,3 billion euros.[89] The Italian government is also trying to promote R&D, allocating post-pandemic recovery funds to the Microelettronica 2, an IPCEI, bringing together Italy and other thirteen member states[90] to boost innovation.[91]

However, Italy's semiconductor growth remains tethered to fragile external raw material supplies. If Italy wants to de-risk its semiconductor supply chain and strengthen indigenous manufacturing capacity, it cannot overlook the risks involved in CRM supply. Italy must anchor its semiconductor expansion around legacy chip production, while embedding CRM resilience by securing recycled material flows domestically and within the EU.

Conclusions and recommendations

Economic security has moved from the periphery to the core of national and EU policymaking as geopolitical shocks – from the Covid-19 pandemic to Russia's invasion of Ukraine and rising US-China tensions – exposed the fragility of global supply chains. The EU, long reliant on stable trade flows and concentrated imports from East Asia, now faces acute vulnerabilities, particularly in CRMs and semiconductors.

In recent years, the EU has launched its Economic Security and De-risking Strategies, centred on supply resilience, technological sovereignty, and reduced overreliance on China, while designing policies and initiatives to de-risk two of the most critical sectors: CRMs and semiconductors. Several member states have followed suit, including Italy, who has expanded and better articulated its

[86] In Catania.

[87] "STMicroelectronics, Dagnino al tavolo Mimit: 'L'azienda vuole valorizzare ulteriormente il sito etneo'", in *CataniaToday*, 11 April 2025, https://www.cataniatoday.it/economia/StMicroelectronics-piano-investimenti-catania-2025.html.

[88] Integration of chiplets – produced through standard semiconductor fabrication processes – into a functional system.

[89] "Chip, ok dell'UE agli aiuti da 1,3 miliardi per l'impianto di Silicon Box a Novara", in *Il Sole 24 Ore*, 18 December 2024, https://www.ilsole24ore.com/art/chip-ok-dell-ue-aiuti-13-miliardi-l-impianto-silicon-box-novara-AGBW9aqB.

[90] Austria, Czech Republic, Finland, France, Germany, Greece, Ireland, Malta, the Netherlands, Poland, Romania, Slovakia and Spain.

[91] Italian Ministry of Enterprises and Made in Italy website: *IPCEI Microelettronica 2 (ME/CT)*, last updated on 11 April 2025, https://www.mimit.gov.it/it/incentivi/ipcei-microelettronica-2.

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regulatory framework to achieve greater strategic autonomy in these two sectors.

To maximise its de-risking regulatory effort, the EU must seize the opportunity presented by the ongoing review of its financial toolbox and trade restrictions to build stronger coordination mechanisms. This includes not only reducing internal divergences among member states but also deepening strategic alignment with like-minded partners such as Japan, which shares common challenges and ambitions in critical sectors like CRMs and semiconductors. As the EU advances its outbound foreign direct investment screening mechanisms, it must also pursue robust cooperation with key allies on the regulation of dual-use technologies.

Simultaneously, the EU must align its internal policy frameworks across interdependent strategic sectors. The disruptions of recent years have laid bare the vulnerabilities arising from fragmented approaches to sectors that are deeply interconnected – such as CRMs, semiconductors, and adjacent technologies like AI. To mitigate these risks, the EU should move away from compartmentalised strategies and, instead, develop integrated approaches – such as a coordinated "Chip Unit" – to address supply chain vulnerabilities from the raw material stage to AI application readiness.

At the national level, Italy is well-positioned to become a central player in the EU's de-risking agenda through its potential in recycling and recovery of CRMs. To capitalise on this strategic advantage, Italy should prioritise regulatory and industrial efforts aimed at becoming Europe's recycling hub, while expanding R&D cooperation with international partners. This would strengthen Italy's position in the CRM and semiconductor value chains, while reinforcing the EU's broader industrial resilience and strategic autonomy.

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List of acronyms

AI	Artificial intelligence
APS	Announced Pledges Scenario
BIS	US Bureau of Industry and Security
CRM	Critical raw material
CRMA	Critical Raw Material Act
DG	Directorate-General
DRC	Democratic Republic of Congo
ESIA	European Semiconductor Industry Association
ESMC	European Semiconductor Manufacturing Company
EU	European Union
EUV	Extreme ultraviolet
EV	Electric vehicle
FDI	Foreign direct investment
HHI	Herfindahl-Hirschman Index
IPCEI	Important Project of Common European Interest
ISPRA	Istituto superiore per la protezione e la ricerca ambientale
MASE	Ministero dell'ambiente e della sicurezza energetica
MoU	Memorandum of understanding
nm	Nanometre
NZE	Net Zero Emissions by 2050
PNRR	Piano nazionale di ripresa e resilienza
R&D	Research and development
REE	Rare earth element
RMD	Raw Material Diplomacy
RMIP	Raw Materials Investment Platform
SRM	Strategic raw material
TSMC	Taiwan Semiconductor Manufacturing Company
US	United States

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Trans-Atlantic Critical Mineral Supply Chain Cooperation: How to Secure Critical Minerals, Battery and Military Supply Chains in the European Theatre

by Fabian Villalobos

Ministry of Foreign Affairs and International Cooperation

ABSTRACT
The intensifying US-China competition has profound implications for critical mineral supply chains (CMSCs), affecting trade, export controls and market dynamics. US and European firms face difficulties competing with China's dominant market position, which has led to shutdowns and restricted access to essential materials. China's state-backed industrial policy, integration of the Communist Party into commercial operations and use of market power for geopolitical leverage have enabled it to control key mineral-technology value chains, complicating international cooperation and raising security concerns. The global push for decarbonisation has increased civilian demand for critical minerals, particularly in new energy technologies, outpacing defence sector needs and limiting its influence in securing resources. In response, both the US and EU have developed strategies to mitigate vulnerabilities in their supply chains, recognising the need for diversified control, crisis management mechanisms and enhanced cooperation. The war in Ukraine has further underscored the urgency of strengthening the defence industrial base, with case studies illustrating the material demands for military technologies such as FPV drones. Drawing on the experiences of South Korea and Japan, and fostering transatlantic cooperation through trade agreements and intelligence sharing, the US and Europe can build greater resilience against geopolitical disruptions and the concentrated, mercantilist nature of current CMSCs.

Critical raw materials | Supply chains | Transatlantic relations | Defence industry | Drones | Ukraine | South Korea | Japan

keywords

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Trans-Atlantic Critical Mineral Supply Chain Cooperation: How to Secure Critical Minerals, Battery and Military Supply Chains in the European Theatre

by Fabian Villalobos*

The ongoing competition between the United States and the People's Republic of China (PRC) has had multifaceted repercussions across a variety of stakeholders. Within the realm of critical minerals supply chains (CMSCs), that competition has spilled into trade, technology export controls, information operations and predatory market behaviour. Domestically, US firms trying to compete in industries with strong Chinese market share have shuttered their operations. Access to critical raw material inputs have been restricted or banned. US allies and partners have been brought together to collaborate on supply chain issues only to find US divergence on trade and security has complicated the decision calculus. Meanwhile, China has continued to advance its control over supply chains and leverage its market power to geopolitical ends.

1. Background

International efforts to reduce carbon emissions are a major driver of the demand for new energy technologies and their raw material inputs, including critical minerals. According to a 2021 United Nations Climate Fact Sheet, the transport sector is responsible for 25 per cent or global CO_2 emissions.[1] According to the US Environmental Protection Agency, that number is 28 per cent for the United

[1] United Nations, *Sustainable Transport Conference Fact Sheet: Climate Change*, 14 October 2021, https://www.un.org/sites/un2.un.org/files/media_gstc/FACT_SHEET_Climate_Change.pdf.

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States.[2] Fossil fuels, and petroleum in particular, dominate as sources of energy. To reduce these emissions, global polices aim to reduce or eliminate the sales of internal combustion engines.[3] With such ambitious goals comes a demand signal for electric vehicles and the subsystems, components and raw materials required for their manufacture. Nations, especially those with established automotive sectors, are keen to capture or hold onto market share and preserve jobs and economic growth.

This large civilian demand signal dwarfs the demand for these same raw materials from the defence and aerospace sector. Important components for weapons systems and equipment produced by the defence industrial base include 'dual-use' technologies, which are usually developed in response to civilian demand by academia and commercial industry but also have military utility.[4] Lithium-ion batteries (LIBs) for energy storage are a prime example. LIBs have captured the greatest share of civilian demand for mobile energy storage, primarily because of their relatively high specific energy, which translates into longer life for mobile electronics and longer range for electric vehicles. LIBs, for the same reason, are needed to fill demand for mobile energy storage on the battlefield, whether for extending operational capabilities that depend on portable energy – and thus conserving JP-8 fuel and reducing the burden on operational energy missions and their logistical footprint – or introducing new capabilities like small unmanned aerial systems (sUAS). However, in dual-use technology markets such as the LIB market, the defence sector is often a small consumer within a larger market driven by demand from commercial applications. In contrast to technologies and capabilities with limited applicability outside warfare, such as munitions, the defence sector has little leverage to shape and influence suppliers to meet specific military requirements. This limits the policy options available to securing materiel and shapes the overall strategy with which to approach risk mitigation.

These challenges to the defence industry posed by vulnerable raw material supply chains are recognised by both the United States and the European Union in documents like the 2023 National Defense Industrial Strategy[5] and the 2024 European Defence Industrial Strategy,[6] respectively. Similarly, the North Atlantic Treaty Organization (NATO) published its first defence-critical raw materials list in 2024.[7]

[2] US Environmental Protection Agency website: *Sources of Greenhouse Gas Emissions*, https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions.

[3] For example, the earliest policy to reduce sales comes from Norway which aims for 100 per cent of new vehicles sales to be from hybrid and electric vehicles by 2025.

[4] Fabian Villalobos et al., *From Mines to Markets in the Middle East and Central Asia. Critical Mineral Suppliers and Dependencies in the U.S. Central Command Area of Responsibility*, Santa Monica, RAND, 2023, https://doi.org/10.7249/RRA2914-1.

[5] US Department of Defense, *National Defense Industrial Strategy*, 16 November 2023, https://www.businessdefense.gov/NDIS.html.

[6] European Commission, *A New European Defence Industrial Strategy: Achieving EU Readiness through a Responsive and Resilient European Defence Industry* (JOIN/2024/10), 5 March 2024, https://eur-lex.europa.eu/legal-content/en/TXT/?uri=celex:52024JC0010.

[7] NATO, *NATO Releases List of 12 Defence-Critical Raw Materials*, 11 December 2024, https://www.nato.int/cps/en/natohq/news_231765.htm.

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Meanwhile, initiatives like China's Made in China 2025 detail the country's ambitions to move itself up the value chain in a variety of sectors, one of which is the New Energy Vehicles – which includes hybrid, electric and fuel cell vehicles. Speeches made by the Xi Jinping himself also highlights the importance of industries like batteries and electric vehicles.[8] Subsequently, Chinese industry, in the form of state-owned enterprises (SOEs) and non-state[9] firms, have enjoyed subsidies and preferential policies to help build a domestic electric vehicle industrial base. Through the use of incentives like access to these subsidies, foreign auto companies have set up partnerships with Chinese firms to transfer technology and manufacturing capabilities. The result has been an early start towards capturing market share of vehicle manufacturing as well as battery manufacturing. Battery manufacturing had an earlier start due to China's role as a manufacturer of mobile electronics components. Now, explicit and implicit subsidies within China have been reduced or removed. The result is domestic demand reduction, increased competition, oversupply and the need to export into other markets for Chinese firms to remain solvent, including the European market.[10]

But electric vehicles are not the only energy technology industry with techno-economic competition.[11] An earlier version of these dynamics played out in production of polysilicon solar photovoltaics, i.e., solar panels. Manufacturers and policy makers in Western countries are keen on not repeating the mistakes made in the solar industry which China now dominates. To incentivise domestic production capacity for electric vehicles and remain competitive with Chinese industry, the United States has enacted legislation like the Bipartisan Infrastructure Law and the Inflation Reduction Act. The European Union has enacted similar legislation in the form of the Green Deal Industrial Plan and Critical Raw Materials Act. Other countries like Japan and the Republic of Korea have their own legislation with more concerted efforts towards securing mineral-technology value chains.[12] Multilateral efforts like the Mineral Security Partnership (MSP) continue to offer a forum for diplomacy and "a collaboration [...] to catalyze public and private investment in responsible critical minerals supply chains globally".[13]

[8] A speech in France, president Xi Jinping delivers remarks alongside French president Emmanuel Macron highlighting the electric vehicles industry. See "Full Text of Xi's Signed Article in French Media", in *Xinhua*, 6 May 2024, http://en.qstheory.cn/2024-05/06/c_984254.htm.

[9] The selection of the term "non-state" as opposed to "private" firm is discussed in the next section.

[10] There is also a need to seek new consumers of these products in adjacent industries with a need for mobile energy storage (e.g., drones).

[11] For a definition of techno-economic competition, see Robert Atkinson, "How to Win Techno-Economic Competition with China", in *The National Interest*, 8 October 2024, https://nationalinterest.org/blog/techland/how-win-techno-economic-competition-china-213136.

[12] Mineral-technology value chain is a term used to describe not just the mining industry and its immediate supply chain ecosystem, but the value chain up to and including the final products minerals are need to produce. This encompasses intermediate chemicals and metals, technology-specific precursors, technology-specific sub-components and components, and articles sold by original equipment manufacturers like consumer products or military platforms, weapons and equipment.

[13] Samantha Carl-Yoder et al., "The Minerals Security Partnership", in *Proceedings of the 70th Annual Natural Resources and Energy Law Institute (2024)*, January 2025.

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Nor are these countries ignoring the demand for the raw materials needed for their manufacture and those needed for military weaponry and equipment. Largely, in response to the security concerns stemming from China – more specifically its activity in the Taiwan Strait, South China Sea and broader Indo-Pacific – but accelerated in response to the ongoing Russian war of aggression in Ukraine, a number of initiatives aimed at increasing the capacity of the defence industrial base have been started or are ongoing. In the United States, the US National Defense Industrial Strategy, the Partnership for Indo-Pacific Industrial Resilience, several White House executive orders relating to both minerals and the defence industrial base, the inclusion of critical minerals in trade policy considerations, and more reveals that CMSCs and mineral-technology value chains continue to be a priority concern and focus of efforts for the US government. A resilient priority means there is still opportunity for cooperation.

2. Underlying problems in critical minerals supply chains

The root of uncertainty in mineral markets is strewn across a variety of factors, but those resulting from China's market activity can be distilled into three categories: (1) China's industrial policy; (2) commercial integration with China's party apparatus; (3) China's economic statecraft. These three areas of market activity influence commodity prices and market power, the ability of foreign firms to operate nominally inside China, and access to Chinese supply by foreign firms. Combining these categories with other industry challenges yields market characteristics that can then inform policies to shape supply chain security.

2.1 PRC industrial policy

The People's Republic of China's non-market development strategy heavily leverages industrial policy to create technology and manufacturing capability and capacity in several interdependent value chains. These mineral-technology value chains are specified through the publication of Five Year Plans written by many state organs, often the Ministry of Industry and Information Technology. As illustrated in the 14th Five Year Plan for Raw Materials Industry Development,[14] the PRC issues guiding statements to direct the activity of state organs and industry including both SOEs and non-state firms.

The development goals reflect a desire for raw materials to "ensure and lead the high-quality development of the manufacturing industry"; in other words, to leverage critical minerals to onshore downstream nodes of technology value

[14] This plan was jointly developed by three state organs: Ministry of Industry and Information Technology, Ministry of Science and Technology and Ministry of Natural Resources. See, Chinese Ministry of Industry and Information Technology, *Notice on Issuing the 14th Five-Year Plan for the Development of Raw Materials Industry* (in Chinese), MIIT Joint Regulation No. 212 of 29 December 2021, https://wap.miit.gov.cn/zwgk/zcwj/wjfb/tz/art/2021/art_2960538d19e34c66a5eb8d01b74cbb20.html.

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chains. There is also a desire to increase the scale of "new materials industry" i.e., to increase supply of materials higher in the value chain. State organs react to directives such as these and issue explicit and implicit subsidies to increase the production capacity of currently operating firms or to encourage the opening of new firms. This can include cheap loans, cheap land and investments in supporting infrastructure for logistics, transportation and energy.

The resulting growth in quantity of firms and production capacity creates extreme competition inside of China to find customers. The competition decreases prices inside China's domestic market and forces some suppliers to seek customers in adjacent industries or to go abroad, pushing out supply into foreign markets. This lowers the cost for domestic Chinese original equipment manufacturers who consume the raw materials or intermediate metals and chemicals while simultaneously increasing prices outside of China thus creating a two-tiered commodity price structures. When coupled with policies that require foreign firms to transfer technology to local firms to gain access to China's domestic consumer market and export quotas that limit the amount of supply from outside of China, it disrupts foreign firms' ability to operate profitably and ultimately to compete. In the United States, the only cobalt refinery shut down its operations only months after starting production.[15] In Sweden, Northvolt, a battery cell manufacturer, is close to filing for bankruptcy.[16]

2.2 Commercial integration with the PRC Party apparatus

A concern from Chinese firms' legislative integration with the Chinese Communist Party (CCP), is that by extension, many other parts of the government and party, including the security apparatus and military services, are included in the decision-making calculus of the firm. This stems from many mechanisms, but an important one relates to SOEs. The first is the State-owned Assets Supervision and Administration Commission of the State Council (SASAC), which reports directly to the PRC State Council, overseas national level SOEs with extensive powers, like the ability assign leadership positions at will.[17] National SOEs cover a wide variety of sectors including mineral extraction, chemical processing, oil and gas, shipping and transportation, port infrastructure and more.

National SOEs are also integral to the PRC's Belt and Road Initiative in the form of ports and infrastructure construction and access to – and extraction of - minerals in Africa, Latin America, Central Asia and elsewhere. As an example, the 14th

[15] Cecilia Jamasmie, "Jervois Halts Idaho Project on Weak Cobalt Prices", in *Mining.com*, 29 March 2023, https://www.mining.com/?p=1113843.

[16] "Northvolt Close to Filing for Bankruptcy in Sweden, Newspaper DN Reports", in *Reuters*, 11 March 2025, https://www.reuters.com/markets/deals/northvolt-close-filing-bankruptcy-sweden-newspaper-dn-reports-2025-03-11.

[17] Li-Wen Lin, "A Network Anatomy of Chinese State-Owned Enterprises", in *World Trade Review*, Vol. 16, No. 4 (October 2017), p. 583-600, DOI 10.1017/S1474745617000210.

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Five Year Plan for Raw Materials Industry Development specifies a goal to "[m]ake leading enterprises bigger and stronger". In the case of rare earth elements, the directive was to "strengthen and expand rare earth enterprise groups, and encourage rare metal enterprises to accelerate integration".[18] Following the release of the plan, consolidation of the rare earth industry did in fact occur in December 2021.[19]

Another concern stems from the CCP presence inside non-state firms.[20] The use of the term "non-state" firm over "private" firm is deliberate to illustrate the implications of the PRC's legal framework. The PRC can request the presence of CCP officials within a company from as high as a seat on the board of directors to as simple as a desk in a corner.[21] Due to the participation of CCP officials in the non-public sector, a distinction must be made to signal that a firm with CCP presence may have a different set of motivations than purely profit-seeking entities in Western countries. However, it is entirely possible for a non-state firm to be both profit-seeking and adherent to broader CCP/PRC goals and act in accordance with one goal or the other depending on the situation. Of course, there is a spectrum of firms that are least likely to adhere to party goals (or least relevant) to those most likely to adhere to party goals. The firms more likely to be relevant to party goals might be those in industries identified in Five Year Plans.

2.3 PRC techno-economic statecraft

The PRC has used several tools of techno-economic statecraft[22] to coerce or otherwise influence the decision-making of other nations or companies. This includes limiting access to its domestic market and export restrictions on technology or raw materials.

Several pieces of legislation have allowed the PRC to limit access to China's domestic market. The first example is from China's 2017 National Intelligence Law,[23] which

[18] As translated.

[19] Fabian Villalobos et al., *Time for Resilient Critical Material Supply Chain Policies*, Santa Monica, RAND, 2022, https://doi.org/10.7249/RRA2102-1.

[20] Jeffrey Becker, "Fused Together: The Chinese Communist Party Moves Inside China's Private Sector", in *CNA InDepth Blog*, 6 September 2024, https://www.cna.org/our-media/indepth/2024/09/fused-together-the-chinese-communist-party-moves-inside-chinas-private-sector.

[21] This CCP presence may be a confluence of the following: "new official institutions to coordinate CCP affairs related to the private sector, 'sending down' a group of 'party-building instructors,' rewarding private business elites with appointments to party positions, and reorienting the work of local party organs to better serve the needs of the private sector". See Xiaojun Yan and Jie Huang, "Navigating Unknown Waters: The Chinese Communist Party's New Presence in the Private Sector", in *China Review*, Vol. 17, No. 2 (June 2017), p. 37-63.

[22] Fabian Villalobos and Morgan Bazilian, "Understanding America's Technological Tit for Tat with China", in *The Hill*, 25 June 2023, https://thehill.com/opinion/4057812.

[23] Center for Naval Analysis (CNA), *China's National Security Laws Implications beyond Borders*, December 2023, https://www.cna.org/quick-looks/2023/chinas-national-security-laws-implications-beyond-borders.

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included expanded authorities to compel the private sector to allow not only access to company records and share collected data, but also proprietary information about critical technologies. This manifested in the push from members of the US Congress to ban the popular social media app TikTok.[24]

A second example is the authority of the Cyberspace Administration of China to enact security reviews of products and services of foreign companies inside China's borders. This authority was invoked when the Cybersecurity Review Office announced investigations into Micron, the US microchip producer,[25] most likely in retaliation for US restrictions on semiconductor and microchips.[26] Without passing the review, Micron is restricted in its ability to sell its products or services in the country.

As mentioned before, the PRC requires foreign companies in some industries who want to operate effectively in China to form joint ventures with domestic firms. For example, in the auto industry, joint ventures were required in some form or another from 1979 until as recently as 2022.[27] These legislations and polices came with stipulations that include technology transfer. Forming joint ventures is also done to gain access to China's domestic tax incentives, which are limited to domestic firms, as was the case with the electric vehicles industry.[28] As mentioned earlier, with limited tax credits now available to incentivise domestic consumption, Chinese firms' search for revenue abroad is causing much tension in foreign EV markets.

The use of export restrictions has also been used as a method of coercion or retaliation by the PRC. A number of export restrictions on critical minerals de facto targeting the United States but which also have broad implications for other countries have been implemented. The restricted materials include ores, processed minerals, metals, intermediate chemicals, downstream products like magnets and manufacturing technology related to these materials. Table 1 records these recent announcements.

[24] Still a developing situation.

[25] China's Cybersecurity Review Office, *Announcement on the Initiation of Cybersecurity Review of Micron's Products Sold in China* (in Chinese), 31 March 2023, https://www.cac.gov.cn/2023-03/31/c_1681904291361295.htm.

[26] Fabian Villalobos and Morgan Bazilian, "Understanding America's Technological Tit for Tat with China", cit.

[27] Yueyuan Selina Xue, Wei Wei and Mark J. Greeven, "China's Automotive Odyssey: From Joint Ventures to Global EV Dominance", in *IMD Innovation Articles*, 26 January 2024, https://www.imd.org/?p=234043.

[28] Frank Bickenbach et al., "EU Concerns about Chinese Subsidies: What the Evidence Suggests", in *Intereconomics*, Vol. 59, No. 4 (July/August 2024), p. 214-221, https://doi.org/10.2478/ie-2024-0044.

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Table 1 | Recent timeline of Chinese export restriction de facto targeting the US

Date	Action (China)	Target country	Preceding action(s)	Date (preceding action)
1 Aug 2023	Export controls on gallium and germanium-related items[29]	None	*USA* – BIS initial rule restricting Chinese access to semiconductors[30] *EU* – Anti-subsidy investigation on Chinese EVs[31]	7 Oct 2022 30 Sep 2023
20 Oct 2023 (announced on this day but implemented in Dec 2023)	Export permits for some graphite products[32]	None	*Netherlands* – New export restrictions on advanced semiconductor equipment[33] *USA* – Restrictions on outbound investment in the semiconductor, quantum information and AI sectors in foreign "countries of concern"[34] *USA* – Expansion of restrictions on artificial intelligence (AI) chips and semiconductor manufacturing equipment; 13 Chinese firms added to the export control list[35]	30 June 2023 9 Aug 2023 17 Oct 2023 (announced on this day but went into effect 30 days after)
21 Dec 2023	Export ban on rare earth processing technology[36]	None	Likely the same as listed in the above row	N/A

[29] International Energy Agency (IEA), *Announcement on the Implementation of Export Control of Items Related to Gallium and Germanium*, last updated 25 April 2025, https://www.iea.org/policies/17893.

[30] Sujai Shivakumar, Charles Wessner and Thomas Howell, "Balancing the Ledger. Export Controls on U.S. Chip Technology to China", in *CSIS Reports*, February 2024, https://www.csis.org/node/109454.

[31] European Commission, *EU Imposes Duties on Unfairly Subsidised Electric Vehicles from China while Discussions on Price Undertakings Continue*, 29 October 2024, https://ec.europa.eu/commission/presscorner/detail/en/ip_24_5589.

[32] Siyi Liu and Dominique Patton, "China, World's Top Graphite Producer, Tightens Exports of Key Battery Material", in *Reuters*, 20 October 2023, https://www.reuters.com/world/china/china-require-export-permits-some-graphite-products-dec-1-2023-10-20.

[33] Arjun Kharpal, "Netherlands, Home to a Critical Chip Firm, Follows U.S. with Export Curbs on Semiconductor Tools", in *CNBC*, 30 June 2023, https://www.cnbc.com/2023/06/30/netherlands-follows-us-with-semiconductor-export-restrictions-.html.

[34] Sujai Shivakumar, Charles Wessner and Thomas Howell, "Balancing the Ledger", cit.

[35] Emily Benson and Thibault Denamiel, "China's New Graphite Restrictions", in *CSIS Commentaries*, 23 October 2023, https://www.csis.org/node/107858.

[36] Edward White, "China Bans Export of Rare Earth Processing Technologies", in *Financial Times*, 21 December 2023, https://www.ft.com/content/5b031db7-23dd-43d3-afe1-cef14817296f.

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Table 1 (continued)

Date	Action (China)	Target country	Preceding action(s)	Date (preceding action)
14 Aug 2024 (announced on this day but implemented in Sep 2024)	Export restrictions on 6 antimony-related products including antimony ore, antimony metals, antimony oxide and gold-antimony smelting and separation technologies; export ban on gold-antimony smelting and separation technology exports[37]	None	*USA* – New or increased tariffs on Chinese EVs, EV batteries, battery parts, semiconductors, solar cells, permanent magnets and certain steel and aluminium products[38]	14 May 2024 (day announced)
3 Dec 2024	Ban on shipments of gallium, germanium, antimony and so-called superhard materials to the United States[39]	USA (first time restrictions specially targeted the US)	*USA* – Second expansion of export restrictions on semiconductor equipment; 140 Chinese entities added to the export control list[40]	2 Dec 2024
4 Feb 2025	Export licenses required for tungsten, tellurium, bismuth, indium and molybdenum	USA	Likely the same as listed in the above row	N/A
4 Apr 2025	Export licenses required for samarium, gadolinium, terbium, dysprosium, lutetium, scandium and yttrium oxides, intermediate compounds and related products (magnets) and manufacturing technology	USA	*USA* – Increased and broad sweeping tariffs placed on imports from China	2 Apr 2025

Source: Author's compilation of various sources.

The motivation behind these export controls is split mostly between retaliation for US technology export restrictions and trade policy. In 2019, the PRC's National Development and Reform Commission suggested restrictions on rare earth products in response to US trade policy.[41] The most recent restrictions have similar

[37] Gracelin Baskaran and Meredith Schwartz, "China's Antimony Export Restrictions: The Impact on U.S. National Security", in *CSIS Critical Questions*, 20 August 2024, https://www.csis.org/node/112028.

[38] Brooks E. Allen et al., "US Announces New Tariffs on Chinese-Origin Goods, with an Exclusion Process", in *Skadden Insights*, 15 May 2024, https://www.skadden.com/insights/publications/2024/05/us-announces-new-tariffs.

[39] Gracelin Baskaran and Meredith Schwartz, "China Imposes Its Most Stringent Critical Minerals Export Restrictions Yet Amidst Escalating U.S.-China Tech War", in *CSIS Critical Questions*, 4 December 2024, https://www.csis.org/node/113585.

[40] "US unleashes Another Crackdown on China's Chip Industry", in *Al Jazeera*, 2 December 2024, https://aje.io/reprvk.

[41] Fabian Villalobos et al., *Time for Resilient Critical Material Supply Chain Policies*, cit.

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motivations. Meanwhile, export restriction on gallium, germanium, graphite and tungsten from 2023 to 2024 appear to be more motivated by US export restrictions on semiconductors and microchips and related technologies. In addition, China's Ministry of Industry and Information Technology suggested that US defence contractors were potential targets for export restrictions in 2020 due to their role in supplying military technology to Taiwan.[42] China restricted urea shipments to South Korea in 2021 amid internal shortages,[43] demonstrating that even when not executed with malign intent, Chinese dominance poses threats to supply chain stability. The origin of these supply disruption concerns stems from the 2010 Diaoyu/Senkaku Island dispute with Japan. This demonstrates that China's market power in mineral-technology value chains is a coercive weapon that can be implemented in many different contexts and may be used in retaliation for actions or activities in contexts not yet envisaged by the United States and its partners.

Along with their use as coercive measures, export restrictions and licensing requirements may also serve an additional purpose – to gather data[44] on importers, company internal operations, their customers, etc. – to find targets for future sanctions by adding them to China's Export Control List or Unreliable Entities Lists.[45]

Finally, these restrictions have had notable impacts on third party suppliers to the United States, who are reliant upon China for these production inputs and then export value added products to the United States.

3. Market characteristics contributing to industry challenges

The market actions of the PRC and Chinese firms, the projected future demand for minerals and the policy responses by developed and developing nations all contribute to challenging market conditions for industry participants. A qualitative industry analysis of the mining industry found that several industry challenges limited competitiveness and shaping market characteristics.[46] Several market characteristics emerge from the challenges in the industry:

[42] Ibid.

[43] See Kim Bo-eun, "Korea Urged to Diversify Material Imports", in *The Korea Times*, 11 November 2021, https://www.koreatimes.co.kr/business/companies/20211111/reporters-notebook-korea-urged-to-diversify-material-imports; Yukyung Yeo, "Urea Crisis Sparks South Korean Supply Chain Revamp", in *East Asia Forum*, 23 August 2024, https://eastasiaforum.org/?p=2339017.

[44] "Japan Complains that China's Export Control Law Is Too Broad and Unclear", in *WorldECR*, 22 June 2023, https://www.worldecr.com/?p=2026650.

[45] The Export Control List prohibits the export of Chinese dual-use items to these companies while the Unreliable Entity List "prohibit[s]...exporting or importing in China or from making new investments in the country". See Liza Lin, "China Adds 15 American Companies to Export-Control List", in *The Wall Street Journal*, 4 March 2025, https://www.wsj.com/livecoverage/trump-tariffs-canada-mexico-china-stock-market-today-03-04-2025.

[46] Tom LaTourrette et al., *The Potential Impact of Seabed Mining on Critical Mineral Supply Chains and Global Geopolitics*, Santa Monica, RAND, 2025, https://doi.org/10.7249/RRA3560-1.

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- *Concentrated industry and geography* – the large market share of Chinese firms at several nodes in mineral-technology value chains is well documented, as is the dominance of other countries like the Democratic Republic of the Congo (DRC) for cobalt extraction and Indonesia for nickel extraction. Owing to this industry clustering, value chains are also highly concentrated in the Indo-Pacific region. This makes disruption from natural disasters or human-factors in the region more impactful to both public and private sector consumers. Not only is there concentration in the primary mining industry, but Chinese firms are also present in ancillary mining product and service industries like mining vehicles, drills, bulk shipping of ores and exploration technologies like drone and satellite data collection. In other words, the problem is bigger than originally thought.

- *Mercantilist behaviour and price volatility* – the governments of both developed and developing countries have demonstrated an inclination toward protectionism and goals other than firm profitability with respect to mineral-technology value chains. This results in wide swings in prices over years, months and sometimes days or even hours. These behaviours, policies and industry activity lowers predictability and drives competitors out of the market. Economic statecraft in the form of sanctions and trade barriers also restrict access to materials. In the case of China, export restrictions may also be precursors to information gathering. So far US trade policy has exempted critical minerals from broader tariffs, but that may change.

- *High barriers to entry* – a variety of factors prevent new firms from entering the exploration, extraction, processing, refining and intermediate chemical production industries and manufacturing of components heavily reliant on these inputs. Oversupply of some minerals creates downward pressure on commodity prices. Regulatory complexity and local stakeholder pushback slows the timeline for project initiation. Limited numbers of processing and refining firms' places constraints on offtake agreements (where buyers agree to buy a certain amount of products at a specific price for a specific time period, which is typical in mining). Buyers have switching costs in terms of limited ability to accept ores and concentrates from new suppliers.[47] Investors prioritising profitability – both public and private – are often disincentivised at greater levels of uncertainty, making it difficult to finance green-field and brown-field projects and any related infrastructure projects.

- *High barriers to exit* – mines are highly specialised assets and closing a mine incurs a cost. Long term storage of tailings and other waste, employee severances and other expenses often incentivises a shuttering mine to continue operating long enough to cover the expenses of the shutdown. The pool of prospective buyers of a mine and mining equipment is also limited, meaning that a mine

[47] However, some offtake agreements are based on annual contracts, which provides opportunities for new entrants.

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may continue to operate – and continue affecting commodity prices – long after the mine has been identified as unprofitable simply because enough prospective buyers are not available. Business or government goals other than profitability also keep mines producing materials longer than would typically be expected.

- *Information opacity* – due to the use of implicit and explicit subsidies inside of China and other countries, it can be difficult to estimate the cost-structure of a mineral commodity price to look for areas of inefficiency and potential innovation. Contracts between suppliers and offtakers are sensitive business materials and not widely available to report prices. It is difficult to anticipate changes in trade policy or export controls and their impact on prices. Many trade codes are not specific enough to provide ample data collection or detailed data analysis to clarify risks and dependencies.

4. Other CMSC problems that complicate decision calculus

In addition to the political risks posed by outsized PRC influence in CMSCs and market characteristics, there are four other areas where CMSCs are exposed to risk and externalities that complicate decision-making:

- *Conflict near or caused by access to mineral resources*. For example, the ongoing Rwanda-DRC conflict has some confluence with the presence and mining of Congolese coltan (tantalum ore) by the Rwandan-backed M23 militia. A memorandum of understanding (MOU) between the European Union and Rwanda for Sustainable Raw Materials Values Chains that includes tantalum[48] further complicates the situation in that signing an MOU with a country explicitly exporting coltan illegally[49] could be seen as an endorsement of the criminal activity and conflict in the DRC. The situation is further complicated by Congolese outreach to the United States for a "minerals-security" agreement and DRC use of private military contractors.[50]

- *Human rights and labour*. The use of forced Uyghur labour by Chinese firms in the Tianjin region is well documented.[51] So too is the presence of artisanal and small-scale mining (ASM). The ASM sector is a major source of employment

[48] European Commission, *EU and Rwanda Sign a Memorandum of Understanding on Sustainable Raw Materials Value Chains*, 19 February 2024, https://ec.europa.eu/commission/presscorner/detail/en/ip_24_822.

[49] Oluwole Ojewale, "Mining and Illicit Trading of Coltan in the Democratic Republic of Congo", in *ENACT Research Papers*, No. 29 (March 2022), https://enactafrica.org/research/research-papers/mining-and-illicit-trading-of-coltan-in-the-democratic-republic-of-congo.

[50] "Blackwater Founder and Trump Ally Strikes Mineral Security Deal with Congo", in *Mining.com*, 17 April 2025, https://www.mining.com/trump-ally-prince-strikes-mineral-security-deal-with-congo.

[51] Laura Murphy et al., *Driving Force: Automotive Supply Chains and Forced Labour in the Uyghur Region*, Sheffield, Sheffield Hallam University Helena Kennedy Centre for International Justice, December 2022, https://shura.shu.ac.uk/34918.

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in several developing countries, engaging approximately 41 million people worldwide, many of whom are women. In some developing countries, ASM often surpasses large, industrial-scale mines in terms of workforce size. Nonetheless, the sector faces significant challenges and is frequently misrepresented, which deters meaningful engagement by downstream manufacturers and consumers.[52]

- *Cyber, information operations and social unrest*. The information domain has not been ignored by Chinese entities. The PRC-linked entity Dragonbridge was identified as targeting information campaigns at US firms trying to diversify the rare earth supply chain.[53] Similar rare earth firms in Australia were hacked by other PRC-linked entities.[54] Social or political discontent with the CMSC industry also presents challenges. For example, protestors in Germany clashed with police as they stormed a Tesla factory.[55] These developments are also vectors for disruption, albeit less well understood.

- *Near- and long-term environmental damage*. Lastly, the environmental effects of mining, processing and refining have put the sector in a bad light. Some long-term effects are still not known, such the potential impacts of seabed mining.[56]

5. Cobalt case study: Supplying a Ukrainian demand signal

The challenges described above can be found within the cobalt supply chain upon which lithium-ion batteries heavily rely. Battery systems now proliferate military weapons and equipment. One such weapon system includes small unmanned aerial vehicles (sUAVs). To illustrate the potential military demand for minerals from a contingency in the European theatre, a case study for the demand for cobalt from first person view (FPV) sUAVs is explored.

Currently, the main exporters of military drones are China and Turkey.[57] Chinese firms in particular control about 80 per cent of the commercial drone market.[58]

[52] Fabian Villalobos et al., *Technology-Driven Opportunities and Risks to Sustainable Development of Critical Minerals in Developing Countries*, Santa Monica, RAND, May 2025, http://www.rand.org/t/PEA4008-1.

[53] Fabian Villalobos, "Emerging U.S. Battery Supply Chain Should Be Wary of China's Information Ops", in *The Hill*, 15 November 2022, https://thehill.com/opinion/3736643.

[54] Paul-Alain Hunt, "Second Australian Rare Earths Producer Suffers Cyber Attack", in *Bloomberg*, 13 June 2024, https://www.bloomberg.com/news/articles/2024-06-13/second-australian-rare-earths-producer-suffers-cyber-attack.

[55] Morgan Meaker, "Climate Protestors Storm Tesla's Europe Gigafactory", in *Wired*, 10 May 2024, https://www.wired.com/story/climate-protestors-storm-teslas-europe-gigafactory.

[56] Tom LaTourrette et al., *The Potential Impact of Seabed Mining*, cit.

[57] Ulrike Franke, "Drones in Ukraine: Four Lessons for the West", in *ECFR Commentaries*, 10 January 2025, https://ecfr.eu/article/drones-in-ukraine-four-lessons-for-the-west.

[58] ChinaPower, *Is China at the Forefront of Drone Technology?*, last updated 25 August 2020, https://

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Given China's dominance of the battery supply chain, there is potential for Chinese firms to influence the supply of batteries for military sUAS. In fact, a RAND study on the autonomous systems industrial base found that military drones had a large dependence on Chinese-sourced batteries.[59] In 2024, China continued to leverage its market power to weaponise its control over supply chains to reduce Ukraine's access to components critical to the production of dual-use drones, including batteries.[60] One such affected company is Skydio, whose CEO posted a message to customers in which he complained that, due to Chinese sanctions, battery supply would be limited for months as alternative sources to China were unlikely to be available for some time yet.[61]

5.1 Demand from Ukrainian UAVs

A recent study by the Kyiv School of Economics estimated that Ukrainian industry has about a four million drones per year production capacity for 2024 with plans to reach production capacities exceeding 10,000 units per month.[62] According to the *Kyiv Independent*, a daily, Ukraine planned to procure 4.5 million drones in 2024.[63]

FPV drones make up a large portion of Ukraine's UAVs.[64] Assuming an FPV drone using a 7in rotor,[65] the typical battery size for that range would be approximately 2200mAh.[66] These batteries can use a cathode active material (CAM) like lithium iron phosphate cathode – which uses no cobalt – or another that does (e.g., LCO or NMC622).[67] The cathode active material loading is assumed to be 96 per cent to

chinapower.csis.org/china-drones-unmanned-technology.

[59] Bradley Wilson et al., *Characterizing the Uncrewed Systems Industrial Base*, Santa Monica, RAND, April 2023, https://doi.org/10.7249/RRA1474-1.

[60] Kollen Post, "Ukraine Builds Drone Parts at Home as China Weaponizes Supply Chain", in *Kyiv Independent*, 10 December 2024, https://kyivindependent.com/as-china-weaponizes-the-drone-supply-chain-ukraine-is-building-more-parts-at-home; Mark Bergen, Mackenzie Hawkins and Gian Volpicelli, "China Is Cutting Off Drone Supplies Critical to Ukraine War Effort", in *Bloomberg*, 9 December 2024, https://www.bloomberg.com/news/articles/2024-12-09/china-is-cutting-off-drone-supplies-critical-to-ukraine-war-effort.

[61] Adam Bry, *China's Sanctions on Skydio*, in Skydio website, 30 October 2024, https://www.skydio.com/blog/chinas-sanctions-on-skydio.

[62] Olena Bilousova et al., *Ukraine's Drones Industry: Investments and Product Innovations*, KSE Institute and Brave1, 4 October 2024, https://kse.ua/wp-content/uploads/2024/10/241004-Brave1-report-v.1.pdf.

[63] Tim Zadorozhnyy, "Ukraine to Buy 4.5 Million FPV Drones in 2025", in *Kyiv Independent*, 10 March 2025, https://kyivindependent.com/ukraine-to-buy-4-5-million-fpv-drones-in-2025.

[64] Tomas Milasauskas and Liudvikas Jaškūnas, "FPV Drones in Ukraine Are Changing Modern Warfare", in *UkraineAlert*, 20 June 2024, https://www.atlanticcouncil.org/?p=774697.

[65] United24 Media claims that, "FPV drones typically come in 7" or 12" base configurations. See Audrey MacAlpine, "Ukraine's Drone Evolution, from Mavic Scouts to Long-Range Strike Weapons", in *United24 Media*, 28 February 2025, https://united24media.com/war-in-ukraine/ukraines-drone-evolution-from-mavic-scouts-to-long-range-strike-weapons-6232.

[66] Chinahobbyline (CNHL), a leading Chinese supplier of drone batteries, recommends using a 2200mAh lithium polymer battery for 7in rotor drones. See CNHL website: *CNHL G+Plus 2200mAh 22.2V 6S 70C Lipo Battery with XT60 Plug*, https://chinahobbyline.com/products/cnhl-gplus-series-2200mah-22-2v-6s-70c-lipo-battery-with-xt60-plug.

[67] CNHL, "Detailed Explanation of 6s Lipo Battery Cathode Material", in *Chinahoobyline Blog*, 18

account for additional materials in the cathode live activated carbon and binder. The specific capacity (mAh·g–1) of LCO and NMC622 is 145[68] and 185,[69] respectively. The mass of CAM present in one 2200 mAh battery using LCO and NMC622 cathodes to power a 7in rotor FPV is thus 14.6 grams and 11.4 grams, respectively. Assuming a total of 4.5 million drones per annum and one battery per drone,[70] the total demand for LCO and NMC622 would be approximately 65.5 metric tons and 51.4 metric tons per annum, respectively.

5.2 Mining and refining capacity needed

Based on stoichiometry of the two CAMs and cobalt sulphate,[71] a common CAM precursor material, Ukrainian demand for cobalt sulphate would be 65.5 metric tons and 10.3 metric tons per annum for LCO and NMC622, respectively. This would be equal to the cobalt sulphate demand from the European refining industry. Finland, Norway, Belgium and France have refineries that may be able to produce cobalt products.[72] Currently, Finland's Umicore Kokkola cobalt refinery's output of cobalt sulphate is about 3,500 metric tons per annum which should satisfy demand.[73] However, Finnish cobalt refineries rely heavily on imports, as domestic mining meets only a small fraction of their overall raw material requirements.[74]

Assuming a 0.35 per cent cobalt ore grade,[75] between 1,870 and 2,900 metric tons of ore would need to be mined in Europe. The European cobalt mining and refining industry is highly concentrated in Finland, where two mines – Kevitsa (Boliden) and Sotkamo (Terrafame) – produced a combined 1,084 metric tons of cobalt as a by-product in 2021.[76] According to Chatham House's Resource Trade.Earth, Europe imported about 2700 metric tons of cobalt ores and concentration in 2022 with

August 2022, https://chinahobbyline.com/blogs/news/detailed-explanation-of-6s-lipo-battery-cathode-material.

[68] Naoki Nitta et al., "Li-ion Battery Materials: Present and Future", in *Materials Today*, Vol. 18, No. 5 (June 2015), p. 252-264, https://doi.org/10.1016/j.mattod.2014.10.040.

[69] Sara Hamed et al., "Optimized NMC622 Electrodes with a High Content of the Active Material: A Comprehensive Study", in *Journal of Power Sources*, Vol. 608 (July 2024), Article 234549, https://doi.org/10.1016/j.jpowsour.2024.234549.

[70] This is a low estimate. Often spare batteries are offered with the drone to minimize drone down time.

[71] The cobalt ratio of cobalt sulphate to CAM is 1:1 and 1:0.2, for LCO and NMC622, respectively. Cobalt sulphate (CoSO4) molar mass = 152.05 grams per mole meaning that it requires about 152 grams and 30.4 grams to produce an equivalent quantity of LCO and NMC622, respectively.

[72] Rifat Jabbar et al., *Polymetallic Nodules and the Critical Minerals Supply Chain: A North American Approach*, Washington, Wilson Center, March 2024, https://www.wilsoncenter.org/node/118396.

[73] Wood Mackenzie, *Umicore Kokkola Cobalt Refinery*, 14 December 2023.

[74] Jukka Konnunaho et al., "A Mining Industry Overview of Cobalt in Finland: Exploration, Deposits and Utilization", in *Geoenergy*, Vol. 1, No. 1 (December 2023), Article geoenergy2023-016, https://doi.org/10.1144/geoenergy2023-016.

[75] The Metals Company reports that the average DRC cobalt ore body percentage is 0.35 per cent. See The Metals Company, *Summary Report Nickel and Cobalt Mining Impact on Terrestrial Carbon Sinks in Sulawesi, Indonesia and Katanga, DRC*, October 2023, https://metals.co/wp-content/uploads/2023/11/Benchmark_Carbon-Sinks_Summary_2023.pdf.

[76] Jukka Konnunaho et al., "A Mining Industry Overview of Cobalt in Finland", cit.

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Finland making up about 1,300 metric tons.[77]

Given the demand signal from Ukrainian FPV drones, Europe has limited ability to meet even the low estimated demand for raw cobalt ore. However, Europe likely has the capacity to refine the cobalt it needs to support the production cobalt sulphate needed for FPV drones at current levels needed by Ukraine.

6. Lessons from abroad: How Korea and Japan learned from disruptions

In meeting the requirements to fulfil future demand, whether during peacetime or during disruption, it is helpful to look to others who have made progress in securing their own supply chains and strengthening economic security. South Korea and Japan have both experienced supply chain disruptions. As such, these two countries have had serious motivation to develop strategies and a legal architecture to strengthen their ability to monitor risk and manage crises. Each has passed legislation and implemented polices that are informative for other countries seeking to better diversify CMSCs and plan for uncertainty.

6.1 South Korea

In the past three years, the Republic of Korea has passed three key pieces of legislation that have created and resourced a supply chain security capability.[78] They are:

1. Act on Special Measures to Strengthen Competitiveness and Stabilise Supply Chain of Materials, Components, and Equipment Industry (25 May 2023);
2. Framework Act on Supply Chain Stabilisation Support for Economic Security (8 December 2023);
3. Special Act on National Resource Security (9 January 2024).

These three laws aim to provide a legal foundation for 14 policy tools that (1) minimise the risk of supply chain disruptions in advance and (2) enable fast recovery when disruptions occur. The result is a Comprehensive Supply Chain Stabilisation Plan resourced by the Ministry of Economy and Finance, designation of roles and responsibilities of ministries and agencies for "policy directions" and "policy tasks" and the creation of the Supply Chain Stabilisation Committee as a cross-government control tower for economic security and supply chain management. These efforts represent a model worth further studying and potentially emulating.

[77] Chatham House resourcetrade.earth website: https://resourcetrade.earth.

[78] Yukyung Yeo, "Urea Crisis Sparks South Korean Supply Chain Revamp", cit.

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6.2 Japan

Japan has created a unique organisation with authorities and resources to help explore and develop new projects in CMSCs. Under Japan's Ministry of Economy, Trade and Industry (METI) is the Japan Organization for Metals and Energy Security (JOGMEC), an independent administrative corporation that executes the policy developed by METI. In 2023, JOGMEC signed an MOU with the European Commission's Directorate General for Internal Market, Industry, Entrepreneurship and Small and Medium Enterprises which highlighted how the two trading partners would work together on energy technology supply chains.[79]

As a policy execution organisation, JOGMEC has expertise on geology, supply chains and capital allocation and investment under one roof. It also does due diligence and feasibility studies in mining, processing or refining projects. So long as a Japanese company invests in a project, JOGMEC can offer liquidity or make loans or loan guarantees to reduce risk to the private company. This organisation was created in the wake of China's ban of rare earth elements to Japan in 2010 and was instrumental in creating Lynas Rare Earth in Australia. JOGMEC represents another model worth further study and potential emulation.

7. Policy objectives for securing supply chains

There are many policy instruments available to countries seeking the security of CMSCs. They vary in their availability and implementation by country, but by analysing market characteristics, it is possible to generalise a set of desirable objectives and capabilities needed to secure supply chains. Generally, they fall into seven categories:

1. *Strategic guidance and coordinating implementation* – providing government policy making and implementation organisations with priorities helps focus efforts. To do so may require a combination of new authorities or resources. Marshalling institutional capabilities with a whole-government-effort is likely to provide better results than a single agency or ministry bearing the brunt of the burden.
2. *Incentivise new supply and demand* – existing contracts among suppliers and buyers limits the ability for new industry entrants to develop new sources of minerals. Alternative mineral resources from waste streams, recycling or seabed minerals likewise face similar challenges. But reducing barriers to entry and stimulating demand with incentives can help attract capital and spur new traditional and alternative mineral supply.
3. *Diversify or localise ownership and control over existing sources* – diversifying

[79] European Commission DG for Internal Market, *Enhancing Cooperation with Japan on Critical Raw Materials Supply Chains through a New Administrative Arrangement*, 6 July 2023, https://single-market-economy.ec.europa.eu/node/2177_en.

the ownership of firms in the mineral-technology value chain so that companies based in foreign entities of concern (FEOC) countries[80] are limited in their influence can reduce political risks. In this way, Inflation Reduction Act incentives not only diversify the location of manufacturing but concurrently helps 'de-risking' efforts. However, just because a firm does not have significant influence by a FEOC country does not mean all risk is eliminated, as illustrated by the pause in operations at Syrah Resources' graphite mine in Mozambique after social unrest broke out.[81]

4. *Coordinate and cooperate with partners and allies* – international cooperation can help overcome the uncertainty of these markets. Diplomatic, finance and trade efforts like the Mineral Security Partnership, the Defense Production Act Investment programme and trade can leverage US ally and partner capabilities and help build relationships with neutral countries where possible. Partnerships with countries like Australia, Canada, the European Union, Japan and South Korea have contributed greatly. These efforts can be expanded to include new partners with capital like Gulf state countries[82] or technical expertise like India.
5. *Risk assessment and crisis management* – though risk can be reduced or mitigated, it will never disappear completely and thus preparing for disruption is essential to ensure resilience. A thorough national risk assessment capability is needed to inform a crisis management plan. Actions to prepare for disruption include stockpiling end-use components, intermediate products and raw ores and concentrates; entering agreements to share resources during periods of disruption; and incentivising the private sector to stockpile. Crisis response could also include resources and processes to help specific firms targeted for sanctions or regulatory overreach as was the case with Micron in 2023.
6. *Leverage existing strengths* – where current market power exists in non-FEOC countries, it can be leveraged against coercive measures from protectionism. This may mean limiting access to domestic markets, investigating trade issues, restricting foreign access to technology of products and services, capturing foreign knowledge and expertise, or enforcing sanctions and other deterrent measures.
7. *Innovate past existing dependencies* – in the longer-term, research and development may be able to keep industries competitive or reduce vulnerabilities. Making existing mineral-technology value chains more efficient by developing new methods of extraction, processing, manufacturing and recycling processes can be effective in remaining competitive with Chinese market power. Meanwhile, research into potential substitute components and raw materials could help reduce overall dependency on the existing industry leaders and promote exploration of alternative sources or discover substitute materials.

[80] These countries as defined in the Inflation Reduction Act are: China, Russia, Iran and North Korea.

[81] See Cullen S. Hendrix, "New-Risking rather than De-Risking: The Challenges in US Efforts to Reduce Dependence on Chinese Critical Minerals", in *RealTime Economics Blog*, 13 December 2024, https://www.piie.com/node/17582.

[82] Fabian Villalobos et al., *From Mines to Markets in the Middle East and Central Asia*, cit.

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7.1 Identifying areas for cooperation between the United States and Europe

Although disagreements exist between US and European foreign policy priorities, it is important to highlight where efforts to secure supply chains could focus should opportunities for cooperation on CMSCs continue to arise. Broadly, these efforts could focus on the following:

- *Reduce barriers to desirable foreign investment, trade, specialised labour and knowledge/skills transfer* – though US trade policy remains unpredictable, there exist frameworks for sectoral trade agreements. The concept is not without precedent – the World Trade Organization Information Technology Agreement is an example.[83] The initial exclusion of critical minerals from tariffs demonstrates their importance to the United States.[84] And with the recent US announcement of Section 232 tariff investigation into critical minerals tariff policy,[85] there may be opportunity for protective sectoral trade agreement talks to share mutual concern and willingness to work on trade policy specifically for critical minerals. Inclusion of trade, investment rules and incentives could be conducted within the Mineral Security Partnership framework.

- *Reduce barriers to sharing data and intelligence* – advancing knowledge of disruption, vulnerabilities and concepts of risk is important for crisis management and risk mitigation. Cooperating on potential new trade codes represents one particular are with high pay off but which may take time to implement. Existing information sharing agreements and could incorporate supply chain risk into their frameworks, for example within NATO.

- *Create shared crisis management mechanisms and processes* – both South Korea and Japan have created national stockpiles. The European Defence Industry Programme includes language on the creation of a stockpile. France has a separate stockpile as well. However, the concept of joint stockpiling between countries has not been explored in depth, although many questions would need to be resolved for the concept to be implemented effectively (who contributes to the stockpile? How would stock be prioritised and released? How would it be funded?) Developing mechanisms, processes and procedures takes time and should be pursued early. Such crisis management mechanisms might also include support packages for Western firms targeted for coercion by the PRC. When Lithuania was subjected to Chinese sanctions, Western firms put

[83] WTO website: *Information Technology Agreement*, https://www.wto.org/english/tratop_e/inftec_e/inftec_e.htm.

[84] Alexander Cook et al., "Critical Minerals Sidestep US 'Liberation Day' Reciprocal Tariffs", in *Fastmarkets*, 4 April 2025, https://www.fastmarkets.com/?p=83400.

[85] White House, *Ensuring National Security and Economic Resilience through Section 232 Actions on Processed Critical Minerals and Derivative Products*, 15 April 2025, https://www.whitehouse.gov/presidential-actions/2025/04/ensuring-national-security-and-economic-resilience-through-section-232-actions-on-processed-critical-minerals-and-derivative-products.

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together an investment package to come to its aid.[86] Likewise, when Micron was investigated in 2023, G7 countries created investment opportunities inside of Japan.[87] These can serve as examples for processes and procedures to be institutionalised.

- *Pool and target resources in foreign production or infrastructure projects* – the Lobito Atlantic Railway project is an excellent example of how foreign development projects can counter the foreign direct investment by China through the Belt and Road Initiative or the "new" Global Development Initiative. However, infrastructure projects in the Indo-Pacific or even within the EU and North America could help benefit their respective mining industries and better integrate equities.

- *Provide expertise to improve mineral resource exploration, management and development in resource-rich countries* – developed economies hold tremendous technical expertise with respect to governance, technology, mineral exploration and more. Developing countries with access to minerals are in need of institutions to better govern and regulate the mining industry. Helping developing countries develop their institutions can also create more clearer and more certain business environments that would benefit multi-national mining corporations originating in the EU and the United States. It also serves to counter China's efforts to exploit grey areas of governance in foreign markets.

- *Increase access to foreign markets for domestic industry and protect domestic investments in foreign countries* – working together to open new markets for foreign direct investment or protecting existing investments can help reduce risks in existing and future supply chains. This could include diplomatic engagement through the MSP Forum or through alternative financing mechanisms.

Conclusion

The high priority of mineral-technology value chains provides an opportunity to continue and to enhance cooperation between the EU and the United States on CMSCs. While policy implementation remains uncertain in some contexts, that should not deter the two parties from continuing to seek areas of common understanding. Cooperation must address underlying issues in CMSCs and the resulting market characteristics in order to be effective. By establishing supply

[86] Bryan Frederick and Howard J. Shatz, *Countering Chinese Coercion Multilateral Responses to PRC Economic Pressure Campaigns*, Santa Monica, RAND, December 2022, https://doi.org/10.7249/PEA796-1.

[87] Annmarie Hordern, "Micron-Japan Deal Counters China 'Coercion,' Rahm Emanuel Says", in *Bloomberg*, 18 May 2023, https://www.bloomberg.com/news/articles/2023-05-19/micron-japan-deal-counters-china-coercion-rahm-emanuel-says.

chain security capabilities based on rigorous analysis and learning lessons from East Asian countries who have delt with CMSC disruption in the past, Western countries can better enhance their supply chain resiliency, should they be faced with supplying materiel for a military conflict like Russia's war of conquest in Ukraine. The future is yet to be determined but within uncertainty lies opportunity.

Updated 25 June 2025

List of acronyms

ASM	Artisanal and small-scale mining
CAM	Cathode active material
CCP	Chinese Communist Party
CMSC	Critical minerals supply chain
DRC	Democratic Republic of the Congo
EU	European Union
EV	Electric vehicle
FEOC	Foreign entities of concern
FPV	First person view
JOGMEC	Japan Organization for Metals and Energy Security
LIB	Lithium-ion battery
METI	Ministry of Economy, Trade and Industry
MOU	Memorandum of understanding
MSP	Mineral Security Partnership
NATO	North Atlantic Treaty Organization
PRC	People's Republic of China
SASAC	State-owned Assets Supervision and Administration Commission
SOU	State-owned enterprise
sUAS	Small unmanned aerial system
sUAV	Small unmanned aerial vehicle
US	United States

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Wired for Resilience: Transatlantic Approaches to Semiconductor Supply Chain Security

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ABSTRACT

Semiconductors, the bedrock of modern economies, have vaulted from niche concern to the centre stage of economic security policy amid the intensifying United States–China technology rivalry. Caught in the middle is the global semiconductor ecosystem, intricately interdependent and now geopolitically exposed. The central policy question is how can the United States and its allies de-risk and diversify without succumbing to techno-nationalist overreach? Securing semiconductor resilience is not a zero-sum nationalist arms race. It is a positive-sum coordination challenge. The United States and Europe must act not just in parallel but in concert – aligning incentives, investing in complementary nodes, and preparing for contingencies around Taiwan and other flashpoints.

US economic policy | Semiconductor industry | Supply chains | Transatlantic relations

keywords

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Wired for Resilience: Transatlantic Approaches to Semiconductor Supply Chain Security

by Barath Harithas*

Introduction

Semiconductors, the bedrock of modern economies, have vaulted from niche concern to the centre stage of economic security policy. The shortages of recent years delivered the lesson with brutal clarity. In 2021, automakers produced eight million fewer vehicles globally[1] due to chip shortages, an output loss exceeding 210 billion US dollars.[2] Average chip inventories plunged from forty days pre-pandemic to under five days in early 2022,[3] leaving industries one supply disruption away from collapse.

This fragility is unfolding amid the intensifying United States–China technology rivalry. Semiconductors have become the strategic high ground of this contest. Washington has moved decisively – blacklisting Chinese AI firms, imposing sweeping export controls on advanced chips and tools,[4] and investing 52 billion US dollars in domestic production and research and development (R&D) through

[1] Paul A. Eisenstein, "What's Ahead for the Auto Industry in 2022?", in *NBC News*, 1 January 2022, https://www.nbcnews.com/business/autos/going-change-auto-industry-2022-rcna10350.

[2] Michael Wayland, "Chip Shortage Expected to Cost Auto Industry $210 billion in Revenue in 2021", in *CNBC*, 23 September 2021, https://www.cnbc.com/2021/09/23/chip-shortage-expected-to-cost-auto-industry-210-billion-in-2021.html.

[3] US Department of Commerce, *Results from Semiconductor Supply Chain Request for Information*, 25 January 2022, https://www.commerce.gov/news/blog/2022/01/results-semiconductor-supply-chain-request-information.

[4] US Bureau of Industry and Security, *Commerce Implements New Export Controls on Advanced Computing and Semiconductor Manufacturing Items to the People's Republic of China (PRC)*, 7 October 2022, https://www.bis.doc.gov/index.php/component/docman/?task=doc_download&gid=3158.

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the CHIPS and Science Act.[5] Beijing, in turn, has doubled down on "science and technology self-reliance",[6] channelling state subsidies into fab construction and chip research.

Caught in the middle is the global semiconductor ecosystem, intricately interdependent and now geopolitically exposed. The central policy question is how can the United States and its allies de-risk and diversify without succumbing to techno-nationalist overreach?

There is a fundamental, but often overlooked, distinction that needs to be made when discussing semiconductor policy.

Each faces distinct risks:

- *Advanced chips* produced at leading-edge process nodes (5nm, 3nm and soon 2nm),[7] are indispensable for high-performance computing and AI applications. To our previous estimate, the installed base of leading-edge graphics processing units (GPUs) in the United States (such as NVIDIA's A100/H100 series) may leap from roughly 5.5 million in 2024 to 160 million by 2030.[8] Meeting this demand will require a majority of the entire wafer capacity of TSMC, the Taiwanese company that dominate semiconductor manufacture globally.[9] Access to leading-edge foundries has thus become a matter of strategic necessity. Such numbers are not mere market curiosities, they have become matters of national security concern for Washington.
- *Legacy chips*, often defined as 28nm and above[10] and less flashy, are the workhorse of industries from automotive to household appliances. Crucially, it was these older chips, not GPUs, that triggered the most acute Covid-era shortages. Demand for 40nm+ microcontrollers and analog chips overwhelmed supply, and even with fabs running at over 90 per cent utilisation, industry could not ramp up overnight.[11] The pain cascaded most visibly through the auto sector, where roughly 95 per cent of the chips in a modern car are legacy nodes.[12]

[5] US Congress, *H.R.4346 - CHIPS and Science Act*, 9 August 2022, https://www.congress.gov/bill/117th-congress/house-bill/4346.

[6] Ardi Janjeva, Seoin Baek and Andy Sellars, "China's Quest for Semiconductor Self-Sufficiency", in *CETaS Briefing Papers*, December 2024, https://cetas.turing.ac.uk/node/303.

[7] Domenico Vicinanza, "The 'World's Most Advanced Microchip' Has Been Unveiled", in *ScienceAlert*, 7 April 2025, https://www.sciencealert.com/?p=157443.

[8] Navin Girishankar et al., "Securing Full Stack U.S. Leadership in AI", in *CSIS Commentaries*, 3 March 2025, https://www.csis.org/node/114983.

[9] Ibid.

[10] Andrew Lee, "Taking on the World's Factory: A Path to Contain China on Legacy Chips", in *FAS Policy Memos*, 6 February 2025, https://fas.org/?p=35848.

[11] US Department of Commerce, *Results from Semiconductor Supply Chain Request for Information*, cit.

[12] Rakesh Kumar, "U.S. Chip Efforts Have Focused on Advanced Semiconductors–But Low-Tech Legacy Chips Could Give China an Unexpected Edge", in *Fortune*, 18 August 2023, https://fortune.com/2023/08/18/u-s-chip-efforts-have-focused-on-advanced-semiconductors-but-low-tech-

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The semiconductor industry is thus fighting a two-front war: one over next-generation compute, the other over last-generation volume.

To date, most headlines and policy firepower have focused on the US response. But Europe remains a crucial, if underappreciated, node in this global system. The Netherlands is home to ASML, sole supplier of extreme ultraviolet (EUV) lithography machines, necessary to fabricate advanced chips.[13] Germany and France host key analog, power and automotive chip manufacturers. Europe may lack leading-edge fab capacity, but it possesses key capabilities in photonics, materials, and mid-tier production.[14]

This paper adopts a macro-to-micro lens to map the US approach to semiconductor resilience: Section 1 examines structural chokepoints in the global supply chain – who makes what, where the bottlenecks lie, and how interdependencies shape vulnerability. Section 2 provides an in-depth view of the US strategy: CHIPS Act implementation, export control enforcement, and the balancing act between onshoring and alliance-building. Section 3 explores the prospects and politics of transatlantic cooperation, from joint investments to aligned outbound investment screening regimes.

The bottom line of this paper is that securing semiconductor resilience is not a zero-sum nationalist arms race. It is a positive-sum coordination challenge. The United States and Europe must act not just in parallel but in concert – aligning incentives, investing in complementary nodes, and preparing for contingencies around Taiwan and other flashpoints.

1. Mapping the semiconductor supply chain: Advanced vs legacy chips

Resilient policymaking starts with knowing the battlefield. The semiconductor supply chain is often labelled "global," but it is not a flat, evenly distributed network. It is a concentrated one where a handful of countries and firms dominate key stages. Critically, the structure diverges sharply between two categories: (1) advanced chips (leading-edge logic and memory); and (2) legacy or mature-node chips (older-process logic, analog, power, microcontrollers, used in cars, Internet of Things devices, industrial electronics).

To understand what the United States and Europe are doing and where they must act together – we first map who holds the chokepoints.

legacy-chips-could-give-china-an-unexpected-edge.

[13] Sébastien Dauvé, "Semiconductors: Can European Industry Regain Ground?", in *Polytechnique Insights*, 2 April 2025, https://www.polytechnique-insights.com/?p=26178.

[14] Ibid.

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1.1 Design and IP: The United States' edge

At the starting line of both supply chains sits design. Here, the United States reigns supreme. US firms like Cadence and Synopsys control ~70 per cent of global electronic design automation (EDA) software,[15] the essential tools engineers use to design chips.

1.2 Fabrication: Differs by node

Fabrication, the delicate process of turning silicon wafers into working chips, reveals the starkest contrast between advanced and legacy supply chains.

a. *Advanced chips (logic and memory)* – For leading-edge logic (≤5nm), Taiwan's TSMC holds ~90 per cent of the global market for cutting-edge logic manufacturing,[16] effectively monopolising supply. For memory (dynamic random access memory/ DRAM, NAND Flash),[17] Samsung (South Korea), SK Hynix (South Korea) and Micron (United States) together control most advanced memory chip production.[18] China's YMTC and CXMT have made strides but face steep technological and sanctions barriers.[19]

b. *Legacy nodes (28nm+ and analog)* – In this space, global production is distributed across a combination of contract foundries and vertically integrated firms. Among the major foundries are UMC (Taiwan), GlobalFoundries (US/Germany/Singapore) and SMIC (China).

In parallel, several leading integrated device manufacturers (IDMs) design and fabricate chips in-house. These include Infineon (Germany), STMicroelectronics (France/Italy), NXP (Netherlands) and Texas Instruments (United States). IDMs are particularly important in sectors like automotive and industrial electronics, where customisation, reliability and long product lifecycles are critical.

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[15] Zeyi Yang, "Inside the Software that Will Become the Next Battle front in US-China Chip War", in *MIT Technology Review*, 18 August 2022, https://www.technologyreview.com/2022/08/18/1058116/eda-software-us-china-chip-war.

[16] US Department of Commerce, *Biden-Harris Administration Announces Preliminary Terms with TSMC, Expanded Investment from Company to Bring World's Most Advanced Leading-Edge Technology to the U.S.*, 8 April 2024, https://www.commerce.gov/node/6670.

[17] DRAM provides high-speed, temporary working memory for active processes, while NAND Flash offers non-volatile storage, retaining data even when power is off.

[18] Jie Ye-eun, "Micron Makes Aggressive HBM Push to Challenge Samsung, SK", in *The Korea Herald*, 13 April 2025, https://www.koreaherald.com/article/10463949.

[19] Chun Byung-soo and Lee Jae-eun, "Samsung's Memory Chip Leadership at Risk as China's CXMT, YMTC Close in", in *The Chosun Daily*, 27 February 2025, https://www.chosun.com/english/industry-en/2025/02/27/6UETWICZ35AGDPJBRO46YZ3OMU.

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China has rapidly expanded mature-node capacity, fuelled by state subsidies, this surge has raised alarms over potential overcapacity and price distortions.[20]

1.3 Equipment and materials: Transatlantic and allied strength

The upstream tools and materials that enable fabrication are where US, European and Japanese firms form a strong "democratic coalition".

ASML (Netherlands) is the world's sole supplier of EUV lithography, indispensable for sub-7nm manufacturing. Without ASML, there is no leading-edge production – a leverage point used in recent export controls. Even for older nodes, ASML holds ~80-90 per cent of the deep ultraviolet (DUV) lithography market,[21] alongside Nikon and Canon (Japan).[22]

Applied Materials, Lam Research, KLA (United States) and Tokyo Electron (Japan) dominate deposition, etch and metrology tools.[23] ASM International (Netherlands) leads in atomic layer deposition.[24] Japan's Shin-Etsu and SUMCO supply most silicon wafers.[25] Europe's Merck KGaA and BASF provide critical chemicals and photoresists.[26]

Ukraine's war-time neon shortages and China's gallium/germanium export restrictions exposed just how fragile some raw material dependencies remain.

1.4 Strategic takeaways

This mapping exercise reveals two broad realities: advanced supply chains are democratic-led. Cutting-edge design (United States), equipment (United States, EU, Japan), and fabrication (Taiwan, South Korea) are controlled by allies but display high geographic concentration risks.

[20] US Bureau of Industry and Security, *Public Report on the Use of Mature-Node Semiconductors*, December 2024, https://www.bis.gov/media/documents/public-report-use-mature-node-semiconductors-december-2024.

[21] Compound & Fire, "ASML: The Semiconductor King Powering the AI Revolution", in *Deep Dives*, 3 May 2025, https://compoundandfire.substack.com/p/asml-the-semiconductor-king-powering.

[22] Ibid.

[23] Barath Harithas and Andreas Schumacher, "Where the Chips Fall: U.S. Export Controls Under the Biden Administration from 2022 to 2024", in *CSIS Commentaries*, 12 December 2024, https://www.csis.org/node/113735.

[24] Javier Correonero, "Upgrading Our Moat Rating to Wide for ASM International and BE Semiconductor", in *Morningstar Equity Research & Insights*, 29 April 2025, https://www.morningstar.co.uk/uk/news/264189/upgrading-our-moat-rating-to-wide-for-asm-international-and-be-semiconductor.aspx.

[25] Mark LaPedus, "Silicon Wafer Market: Upturn, Higher Prices", in *Semiecosystem*, 24 April 2024, https://marklapedus.substack.com/p/silicon-wafer-market-upturn-higher.

[26] The Business Research Company, "Photoresist Electronic Chemical Market Forecast 2025-2034: Growth Dynamics, Emerging Trends, and Strategic Opportunities", in *Latest Global Market Insights*, 28 April 2025, https://blog.tbrc.info/?p=185142.

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Legacy supply chains are more globally distributed but vulnerable to China's rise. Mature-node and analog chips are scattered across the United States, EU, Japan, Taiwan and China, with Beijing's subsidised overcapacity threatening to destabilise global markets.

2. The US semiconductor resilience strategy: The sword and the shield

For decades, US semiconductor strategy was laissez-faire – let market forces sort it out. Over the past two years, Washington has launched the most ambitious industrial policy effort in a generation; spending big, regulating hard, and realigning national priorities to shore up chip supply chains.

This section dissects the pillars of the US strategy: (1) *massive investment incentives* (CHIPS Act subsidies and tax credits); (2) *workforce and talent development* to incubate the next generation; (3) *export controls and tech protection* to block adversarial advances; (4) *trade enforcement tools* like tariffs and Section 301 investigations to combat non-market distortions.[27]

Throughout, one theme stands out: while the United States aims to claw back advanced logic and memory production, it is also awakening belatedly to the need to protect its legacy chip foundations.

2.1 The CHIPS Act: Big money, big bets

The centrepiece of the US resilience playbook is the CHIPS and Science Act of 2022, which commits 52.7 billion US dollars to the domestic semiconductor industry:

- 39 billion in direct manufacturing incentives,
- 13.2 billion for R&D and workforce development, and
- a 25 per cent investment tax credit for capital expenditures.[28]

This injection aims to reverse the slide in US global manufacturing share, which fell from ~37 per cent in the 1990s to ~12 per cent by 2020.[29]

[27] Section 301 investigations refer to investigations opened by the Department of Commerce under the 1974 Trade Act, which allows for the imposition of tariffs as retaliation against foreign discrimination of US companies.

[28] David Plotinsky and JiaZhen Guo, "First CHIPS for America Funding Opportunity Provides $39B for Domestic and International Semiconductor Manufacturers", in *LawFlash*, 2 March 2023, https://www.morganlewis.com/pubs/2023/03/first-chips-for-america-funding-opportunity-provides-39b-for-domestic-and-international-semiconductor-manufacturers.

[29] Semiconductor Industry Association (SIA), *SIA Applauds Enactment of CHIPS Act*, 9 August 2022, https://www.semiconductors.org/sia-applauds-enactment-of-chips-act.

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By the end of 2024, the Department of Commerce had awarded ~30.6 billion US dollars across nineteen companies, with another ~1.7 billion US dollars preliminarily proposed.

The headline recipients are the giants of semiconductor manufacturing:
- TSMC: 6.6 billion US dollars for two fabs in Arizona (4/5nm production by 2025, 3nm by 2027-28).[30]
- Intel: Up to 7.86 billion US dollars to support fabs in Ohio, Arizona and Oregon, plus advanced packaging in New Mexico.[31]
- Samsung: 4.7 billion US dollars for two Texas fabs and an R&D centre.[32]
- Micron: 6.2 billion US dollars for a DRAM megafab in New York and expansion in Idaho.[33]

Crucially, federal dollars unlock massive private and state co-investment. Intel's grant underpins a 100 billion US dollars "Ohio One" megafab;[34] Micron's New York plans involve ~40 billion US dollars over a decade, with ~5.5 billion in state incentives.[35]

This subsidy model directly tackles the cost gap between US and overseas fab construction, helping to level the playing field against subsidised competitors.

2.2 Beyond the giants: Tacking the legacy chips problem

While the United States aims to claw back advanced logic and memory production, it is also awakening belatedly to the need to protect its legacy chip foundations:
- GlobalFoundries: 1.5 billion US dollars to expand legacy-node capacity in New York and Vermont.[36]
- Texas Instruments: 1.6 billion US dollars for new analog fabs in Texas and Utah.[37]

[30] TSMC, *TSMC Arizona and U.S. Department of Commerce Announce up to $6.6 Billion in CHIPS Act Funding*, 8 April 2024, https://pr.tsmc.com/english/news/3122.

[31] US Department of Commerce, *Biden-Harris Administration Announces CHIPS Incentives Award for Intel*, 26 November 2024, https://www.commerce.gov/node/6998.

[32] National Institute of Standards and Technology (NIST) website: *Samsung Electronics (Texas)*, https://www.nist.gov/node/1855111.

[33] Jingyue Hsiao, "Micron Secures $6.165 Billion in CHIPS Act Funding to Advance U.S. Memory Manufacturing", in *Digitimes*, 11 December 2024, https://www.digitimes.com/news/a20241211VL200.

[34] Reuters, "Intel Plans $20 Billion Chip Manufacturing Site in Ohio", in *CNBC*, 21 January 2022, https://www.cnbc.com/2022/01/21/intel-plans-20-billion-chip-manufacturing-site-in-ohio.html.

[35] Micron Technology, *Micron Announces $40 Billion Investment in Leading-Edge Memory Manufacturing in the US*, 9 August 2022, https://investors.micron.com/node/43921.

[36] GlobalFoundries, *GlobalFoundries and U.S. Department of Commerce Announce Award Agreement on CHIPS Act Funding for Essential Chip Manufacturing*, 20 November 2024, https://gf.com/?p=12790.

[37] Texas Instruments, *Texas Instruments Signs Preliminary Agreement to Receive up to $1.6 Billion in CHIPS and Science Act Proposed Funding for Semiconductor Manufacturing in Texas and Utah*, 16 August 2024, https://www.ti.com/about-ti/newsroom/news-releases/2024/2024-08-16-texas-instruments-signs-preliminary-agreement-to-receive-up-to--1-6-billion-in-chips-and-science-act-proposed-funding-for-semiconductor-manufacturing-in-texas-and-utah.html.

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- Wolfspeed: 750 million US dollars Funding for a silicon carbide (SiC) power chip fab in North Carolina.[38]

Significantly, the United States is also investing in packaging and assembly – historically dominated by Asia. Amkor, one of the top global players in outsourced semiconductor assembly and test (OSAT), received 407 million US dollars to build a state-of-the-art facility in Arizona.[39]

This diversified funding approach reflects a deliberate shift – the United States is not just trying to plant a few advanced fabs but to rebuild an integrated semiconductor supply chain onshore.

2.3 Export controls: Buying time by kneecapping rivals

If subsidies represent the carrot, export controls are the stick.

In October 2022, recognising the escalating computational demands of frontier AI,[40] reliant on thousands of the most advanced microprocessors and memory chips, the United States moved to weaponise its dominance over critical chokepoints[41] in the global semiconductor supply chain, which China was dependent on. It was a bold act of bureaucratic foresight – the United States had anticipated the importance of AI before ChatGPT 3.5 made it undeniable just a month later.[42]

The fact that the complex supply chains needed to produce advanced semiconductors were concentrated in the United States and a small number of allied countries further provided a singular opportunity for export control revision.

The controls targeted the sale of the following:
- Advanced semiconductors leading producers: NVIDIA, AMD, Intel, Broadcom (United States), Samsung, SK Hynix (South Korea)
- Electronic design automation (EDA) software market leaders: Synopsys,

[38] Wolfspeed, *Wolfspeed Announces $750M in Proposed Funding from U.S. CHIPS Act…*, 15 October 2024, https://www.wolfspeed.com/company/news-events/news/wolfspeed-announces-750m-in-proposed-funding-from-us-chips-act-and-additional-750m-from-investment-group-led-by-apollo-galvanizing-global-leadership-in-delivering-next-generation-silicon-carbide.

[39] Amkor Technology, *Biden-Harris Administration Announces CHIPS Incentives Award with Amkor Technology to Bring End-to-End Chip Production to the U.S.*, 20 December 2024, https://amkor.com/blog/biden-harris-administration-announces-chips-incentives-award-with-amkor-technology-to-bring-end-to-end-chip-production-to-the-u-s.

[40] Jaime Sevilla and Edu Roldán, "Training Compute of Frontier AI Models Grows by 4.5x per Year", in *Epoch AI*, 28 May 2024, https://epoch.ai/blog/training-compute-of-frontier-ai-models-grows-by-4-5x-per-year.

[41] Saif M. Khan, "Securing Semiconductor Supply Chains", in *CSET Policy Briefs*, January 2021, https://cset.georgetown.edu/publication/securing-semiconductor-supply-chains.

[42] Bernard Marr, "A Short History of ChatGPT: How We Got to Where We Are Today", in *Forbes*, 19 May 2023, https://www.forbes.com/sites/bernardmarr/2023/05/19/a-short-history-of-chatgpt-how-we-got-to-where-we-are-today.

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Cadence (United States), Siemens EDA (Germany/United States)
- Semiconductor manufacturing equipment lithography: ASML (Netherlands), Tokyo Electron (Japan), Process Tools: Lam Research, Applied Materials (United States)
- Critical components needed to develop machinery metrology/inspection: KLA Corporation (United States), Light Sources: Cymer (United States)[43]

The United States operated with transitive precision. First, it blocked direct access to the advanced semiconductors needed for frontier AI development. Then, it denied Beijing the tools the software and machinery needed to design and fabricate the chips themselves. Finally, it pre-empted any efforts to indigenise by obstructing access to the critical components required to build the machinery domestically. The cascading sequence of restrictions aimed to trap China in a technological cul-de-sac and sustain the United States' dominance.[44]

Crucially, the United States secured alignment from key allies:
- The Netherlands expanded controls to cover advanced DUV lithography, alongside its long-standing EUV export bans.
- Japan imposed controls on etching, deposition, and cleaning tools.

2.4 Trade enforcement: Tariffs and Section 232/301 hammer

In late 2024, Washington escalated its toolkit by launching a Section 301 investigation[45] into China's industrial policies, particularly targeting mature-node semiconductors. The probe, authorised under the same statute that fuelled the first Trump-era trade war, targets Beijing's extensive subsidies and non-market practices. If confirmed, the investigation could result in:
- tariffs on Chinese semiconductor imports;
- restrictions on US firms sourcing certain Chinese legacy chips; or
- negotiated agreements to moderate Chinese overproduction.

The strategic aim is to prevent a repeat of the solar panel or steel overcapacity crisis, where Chinese state-subsidised surpluses drove Western competitors out of business.

2.5 Gaps, risks and the Trump factor

Despite its ambition, the US semiconductor strategy faces three glaring risks:
1. Funding sustainability: The CHIPS Act is a one-off, front-loaded package. Operating support, follow-on R&D funding ("CHIPS 2.0"), and ecosystem

[43] Barath Harithas and Andreas Schumacher, "Where the Chips Fall", cit.
[44] Ibid.
[45] US Trade Representative (USTR), *USTR Initiates Section 301 Investigation of China's Acts, Policies, and Practices Related to Targeting of the Semiconductor Industry for Dominance*, 23 December 2024, https://ustr.gov/node/13974.

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resilience (e.g., substrates, advanced packaging) may need additional waves of investment. Political appetite for further subsidies remains uncertain, especially in a more fiscally hawkish environment.

2. Political uncertainty: President Donald Trump has signalled scepticism toward the CHIPS Act, calling it "government picking winners and losers". He might scale back subsidies, impose new conditions or prioritise tariffs over allied cooperation. Moreover, Trump-era tensions with Europe – over auto tariffs, defence spending, and trade balances – could disrupt delicate transatlantic semiconductor alignments.
3. Overcapacity and geopolitical timing: If the global fab buildout outpaces demand (especially in cyclical sectors like memory), the result could be a self-inflicted glut. And crucially, even with aggressive reshoring, the United States will remain reliant on Taiwan's TSMC through the late 2020s. A Taiwan contingency would imperil global advanced chip supply before US domestic fabs come fully online.

3. Transatlantic semiconductor cooperation: What's realistic, what's necessary

It is easy to wax lyrical about "transatlantic partnership" in semiconductors. After all, the United States and Europe share democratic values, advanced industrial bases and deep economic ties. But the reality is harder. Both sides have differing industrial traditions, their own domestic pressures, and (especially under a second Trump Administration) increasingly transactional instincts.

This section cuts through the niceties to ask: what kinds of US–EU semiconductor cooperation is realistically feasible, even under political strain? Which ideas are merely diplomatic window dressing, and which can actually deliver meaningful resilience benefits?

A pragmatic, layered approach is essential: focus on quiet, technocratic cooperation below the political surface; leverage areas of unique mutual dependency (where neither side can go it alone); and target a few novel mechanisms that do not depend on fragile political goodwill. Semiconductor resilience, after all, is not a diplomatic talking point, it is an operational necessity.

3.1 Aligning incentives without fighting over the same fabs

Both the United States and EU have launched bold industrial strategies – the CHIPS Act and the European Chips Act – each aiming to rebuild domestic semiconductor capacity. But without coordination, they risk competing for the same handful of global players (TSMC, Intel, Samsung) or over-incentivising the same segments while leaving others neglected.

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To address this, the United States and EU created a subsidy transparency mechanism under the Trade and Technology Council (TTC) to share details on grant programmes and capacity expansion plans. This is a good start, but the TTC is politically fragile and may not survive the Trump factor or broader US–EU tensions.
A practical fallback is for agencies like the US Department of Commerce and the European Commission to establish a quiet, staff-level coordination channel that persists even if the TTC falters. This could involve informal "gentlemen's agreements" to avoid bidding wars – e.g., the EU focuses subsidies on mature-node, automotive and power chips (its core strengths), while the United States leans into leading-edge logic, memory and advanced packaging. This soft division of labour is already emerging in practice: Europe's 10 billion euro support package for Intel's Magdeburg fabs and its projects with STMicroelectronics and Infineon tilt toward European industrial niches, while the United States bets big on Arizona, Ohio and Texas for bleeding-edge fabs.

It is unrealistic to expect perfectly harmonised subsidy strategies – both sides will pursue national interests – but targeted transparency to avoid wasteful duplication is politically feasible and economically wise.

3.2 Keeping the export controls front aligned

One of the clearest US–EU successes so far has been their alignment on export controls targeting China's access to advanced semiconductor tools and equipment. The Dutch (with ASML) and the Japanese came on board after extensive US diplomatic pressure in 2023.[46]

But as the United States ratchets up its rules, tightening thresholds for AI chip performance, closing loopholes, or adding new controlled technologies – it will need EU alignment.

The most feasible way forward here is continued task force coordination at the technocratic level – not grand political gestures. US and EU officials should:
- share advance notice of planned export rule changes;
- conduct joint technical assessments of which tools, components or software to cover; and
- coordinate enforcement intelligence (for example, tracking suspicious export routes or front companies).

This does not require a new formal treaty or expanded TTC mandate. It requires well-staffed, well-resourced regulatory teams with routine, confidential backchannel communication – something that can survive political turbulence, even under a more unilateralist US Administration.

[46] Barath Harithas and Andreas Schumacher, "Where the Chips Fall", cit.

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3.3 Crisis coordination: Early warning, not empty summits

Russia's invasion of Ukraine, China's export restrictions on gallium and germanium and fears over Taiwan prompted the United States and EU to establish a joint early warning mechanism for semiconductor disruptions.

This is one of the most pragmatic and feasible cooperation areas: it is purely operational, benefits both sides, and is largely insulated from high-level political drama.

The United States and EU should:
- expand it to include like-minded partners – Japan, South Korea, Taiwan, and possibly the United Kingdom – creating a global semiconductor alert network;
- develop pre-agreed crisis protocols, such as coordinated release of stockpiles, surge production plans or reciprocal fallback supply arrangements.

It is unrealistic to expect full-blown "allied allocation plans" for something like a Taiwan crisis (where geopolitics would overwhelm bureaucratic plans), but even lightweight contingency playbooks can reduce chaos in moments of acute supply shock.

3.4 Joint R&D and standards: Quiet wins, not grandiose pledges

Joint US–EU research programmes are often promised in high-level communiqués but deliver little without concrete funding and institutional mechanisms.

Here, a practical and novel step would be to launch:
- A Transatlantic semiconductor research fund: Even a modest 100–200 million US dollars co-funded programme (matching US and EU money) that supports joint university-industry projects in areas like post-silicon materials, advanced packaging, or low-energy computing. The Horizon Europe programme could link to US National Science Foundation calls, using joint evaluation panels and shared IP frameworks.
- A standards cooperation initiative: Focused not on broad political statements but on niche, actionable domains – e.g., hardware-based security standards, chip traceability protocols, or green manufacturing benchmarks. Agencies like the US National Institute for Science and Technology and the European Telecommunications Standards Institute and European Committee for Electrotechnical Standardisation can work together to harmonise standards, giving Western firms a head start and indirectly setting global norms.

These efforts are low political cost and high resilience payoff, especially if framed as technical collaborations, not geopolitical grandstanding.

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3.5 Co-investment mechanisms: A semiconductor venture fund

One genuinely underexplored idea is a US–EU joint semiconductor venture fund targeting startups developing critical supply chain technologies:

- lithography alternatives (beyond EUV);
- AI-driven EDA tools;
- novel semiconductor materials (beyond silicon, GaN, SiC);
- advanced packaging solutions.

By co-investing, the United States and EU can reduce reliance on Chinese capital, share intellectual property, and ensure dual-location development and where both sides co-fund and co-own technology breakthroughs.

This would require modest initial capital (hundreds of millions, not tens of billions) but would have a disproportionately large symbolic and strategic impact, signalling deep transatlantic tech alignment.

3.6 Practical recommendations

Given these realities, US–EU semiconductor cooperation should focus on:

- *institutional durability*: Embed coordination mechanisms in regulatory agencies and industrial bodies, not just high-level councils.
- *technocratic quiet channels*: Keep lines open at the working level, even if political leaders clash.
- *low-cost, high-impact initiatives*: Prioritise early warning systems, joint R&D funds, co-investment vehicles, and standards alignment over sweeping new treaties.
- *mutual fallback mechanisms*: Quietly prepare reciprocal support plans for severe supply disruptions.

4. Conclusion: A resilience architecture for an uncertain era

The return of Trump to the White House has already upended many assumptions in US–EU relations. The TTC, once envisioned as a flagship mechanism for transatlantic coordination, now teeters under the weight of an "America First" doctrine sceptical of formal alliances and multilateral structures. Yet, the cold reality of the semiconductor supply chain imposes constraints that even political shifts cannot fully override.

No matter the rhetoric from Washington or Brussels, the fact remains: the United States and Europe are bound together in this domain by necessity, not sentiment. The United States needs ASML's lithography and Europe, for its part, needs US chip design, equipment and critically the diplomatic muscle to sustain a coordinated export control regime on China.

The challenge ahead is clear. Policymakers on both sides of the Atlantic must now shift from headline-grabbing pledges to pragmatic, institutionalised cooperation that can endure even under strained political conditions. That means embedding early warning mechanisms, coordinating industrial incentives, and aligning export control updates at the agency level – quiet, operational work that does not require top-level political harmony to succeed. It also means embracing a transactional framing when necessary – cooperation not as a diplomatic favour, but as a mutual economic and security imperative.

The Trump Administration's scepticism toward multilateralism may complicate this work, but it does not erase its necessity. Indeed, the irony is that the more transactional and volatile global politics becomes, the more valuable and stabilizing these technical, bottom-up cooperation mechanisms will be.

In short, the United States and Europe are now in the business of rewiring the global semiconductor circuit for security and durability. It will not be elegant, it will not be smooth, but it is, unmistakably, the work of this geopolitical moment.

Updated 12 June 2025

List of acronyms

ASML	Advanced semiconductor materials lithography
CXMT	ChangXin Memory Technologies
DRAM	Dynamic random access memory
DUV	Deep ultraviolet
EDA	Electronic design automation
EU	European Union
EUV	Extreme ultraviolet
GaN	Gallium nitride
GPU	Graphics processing unit
IDM	Integrated device manufacturer
nm	Nanometre
OSAT	Outsourced semiconductor assembly and test
R&D	Research and development
SiC	Silicon carbide
SMIC	Semiconductor Manufacturing International Corporation
SUMCO	Silicon United Manufacturing Corporation
TMSC	Taiwan Semiconductor Manufacturing Company
TTC	Trade and Technology Council
UMC	United Microelectronics Corporation
US	United States
YMTC	Yangtze Memory Technology Co.

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Aligning US-EU Energy Grid Strategies: From Risk to Resilience

by Antonia Wunnerlich and Penelope Naas, with contribution from Julia Tréhu

Ministry of Foreign Affairs and International Cooperation

ABSTRACT

The strategic importance of critical energy infrastructure has come into sharp focus amid rising geopolitical tensions, extreme weather events, supply chain disruptions and hybrid threats. The April 2025 blackout across the Iberian Peninsula underscored that key infrastructure relies on a well-functioning power grid. In both the United States and Europe, aging grids – designed for centralised, one-way electricity flow – struggle to accommodate the two-way, variable inputs required by renewable energy sources. As electricity demand surges due to electrification and data centre growth, grids face investment gaps, mounting congestion, supply chain concerns and regulatory challenges. Meanwhile, China's rapid rise as a global grid innovator and supplier introduces new risks to transatlantic technology stacks, including cybersecurity threats and supply chain dependencies. A coordinated US-EU approach to grid and transmission technology offers a strategic path to de-risking. Such cooperation could enhance resilience, foster competitiveness, reduce reliance on rivals and drive innovation and job creation.

Energy infrastructure | Electrical grids | Supply chains | USA | European Union | China | Transatlantic relations

keywords

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Aligning US-EU Energy Grid Strategies: From Risk to Resilience

by Antonia Wunnerlich and Penelope Naas,
with contribution from Julia Tréhu*

Introduction

The strategic importance of critical energy infrastructure has come into sharp focus in recent years. Geopolitical tensions, extreme weather events, supply chain disruptions and hybrid threats underscore that a reliable and resilient energy system is vital to national and economic security. The power blackout across the Iberian Peninsula on 28 April 2025 serves as a powerful reminder that key infrastructure – from transportation and manufacturing to banking systems and public health – relies on a well-functioning power grid.

Yet on both sides of the Atlantic, grid infrastructure is aging and under strain. In the United States, more than 70 per cent of transmission lines are over 25 years old,[1] while in the European Union, around 40 per cent of distribution lines are over 40 years old.[2] These systems were largely built for a centralised, one-way flow of electricity – not the two-way, variable inputs required by renewable energy sources such as wind and solar. Both grid systems suffer from investment gaps, mounting congestion, supply chain concerns and regulatory and planning challenges. As the share of renewables grows, maintaining grid stability – balancing supply and

[1] US Department of Energy, *What Does It Take to Modernize the U.S. Electric Grid?*, 19 October 2023, https://www.energy.gov/node/4834193.

[2] European Court of Auditors, *Making the EU Electricity Grid Fit for Net-Zero Emissions*, April 2025, https://www.eca.europa.eu/en/publications/RV-2025-01.

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demand, regulating frequency and managing real-time fluctuations – requires major upgrades, including advanced technologies and energy storage solutions.

Electricity demand is rising due to the rapid proliferation of data centres supporting artificial intelligence (AI), cloud computing and cryptocurrencies, as well as the electrification of vehicles and resurgence of domestic manufacturing.[3] Yet this leap in next-generation technologies is being built atop an aging grid infrastructure – one that was never designed to handle the scale, speed or complexity of today's energy demands. An outdated or vulnerable grid undermines the ability of advanced economies to scale digital infrastructure, support industry and power next-generation technologies. De-risking the grid and ensuring its reliability amid this transition is therefore not just a technical challenge, but a strategic imperative for economic competitiveness and innovation.

Modernisation and reinforcement require significant investment, and countries such as the People's Republic of China (PRC) are investing heavily in transmission grid infrastructure, both domestically and internationally.[4] China's steep rise as a global grid innovator raises questions about the future security of US and European grid technology stacks. Advanced hardware and software systems are often sourced globally, exposing vulnerabilities to supply chain disruptions.

The digitalisation of energy infrastructure also opens new channels for interference, including security vulnerabilities, cyberattacks and espionage. As the United States and Europe invest in new infrastructure to meet rising demand, producing and sourcing next generation technologies with trusted partners will become important both for domestic and allied security. Leveraging economic instruments such as strategic procurement and targeted industrial policy can help protect transatlantic critical infrastructure, as well as foster local innovation, job creation and new market opportunities.

Growing strategic vulnerabilities across the transatlantic energy system require increased attention from policymakers. By aligning their efforts, the United States and Europe can build a more robust and innovative energy future. In this piece, we explore the current landscape and identify four critical parts of the energy grid technology stack. We highlight policies that have been deployed to advance transatlantic development of these technologies, as well as new areas of opportunity. Finally, we propose a series of concrete actions that can underpin a coordinated transatlantic strategy.

[3] US Energy Information Administration (EIA), *After More than a Decade of Little Change, U.S. Electricity Consumption Is Rising Again*, 13 May 2025, https://www.eia.gov/todayinenergy/detail.php?id=65264.

[4] "China Accelerates Grid Spending to Absorb Deluge of Solar Power", in *Bloomberg*, 20 March 2025, https://www.bloomberg.com/news/articles/2025-03-20/china-accelerates-grid-spending-to-absorb-deluge-of-solar-power.

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1. The electrical grid

The electrical grids of the United States and Europe are intricate infrastructures of power plants, high-voltage transmission networks and distribution systems designed to deliver electricity across large geographic areas. Electricity systems can be divided into three main stages: generation, where electricity is produced; transmission, where it is transported over long distances via high-voltage lines; and distribution, where it is delivered to homes and businesses. Across all stages, the grid depends on advanced technologies – including transformers and control mechanisms – to maintain safety, stability and efficiency throughout the network.

Both the US and European grid systems face a common set of structural and operational challenges that are further complicated by the integration of large-scale renewable energy. Much of the US and European grid systems were built in the mid-to-late 20th century.[5] Obstacles to modernisation include fragmented governance frameworks across multiple jurisdictions, a lack of coordinated investment and inconsistent financial incentives due to mixed public-private ownership models.

Due to increasingly critical energy needs, both the United States and EU are embarking on efforts to expand capacity and individually strengthen their grids. On 8 April 2025, US President Donald Trump issued an executive order aimed at improving the reliability and security of the US grid, with proposals to align infrastructure with growing power generation.[6] Meanwhile, the European Commission has prioritised an update to its grid legislation as part of its broader push for competitiveness and clean energy.[7] The Russian Federation's ongoing geopolitical pressure has only added urgency, accelerating Europe's drive to modernise its grid and better connect countries to the Continental Europe Synchronous Area (CESA).

These efforts unfold within complex regulatory environments. In the United States, grid policy is shaped by a patchwork of federal, state and regional authorities. The Federal Energy Regulatory Commission (FERC) oversees interstate transmission and wholesale electricity markets, while state public utility commissions (PUCs) regulate retail electricity rates and provide state-level oversight. Regional transmission organisations (RTOs) and independent system operators (ISOs) further complicate governance, each with distinct rules and planning processes.

[5] US Department of Energy, *What Does It Take to Modernize the U.S. Electric Grid?*, cit.; and European Court of Auditors, *Making the EU Electricity Grid Fit for Net-Zero Emissions*, cit.

[6] White House, *Strengthening the Reliability and Security of the United States Electric Grid*, 8 April 2025, https://www.whitehouse.gov/presidential-actions/2025/04/strengthening-the-reliability-and-security-of-the-united-states-electric-grid.

[7] European Commission DG for Energy, *Commission Collects Views in Preparation of the European Grids Package*, 13 May 2025, https://energy.ec.europa.eu/node/6600_en.

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American grid development is often reactive and fragmented, hindered by jurisdictional divides and inconsistent federal authority.[8] Permitting delays are a major bottleneck. Projects can take over a decade due to complex inter-jurisdictional reviews, limited federal siting authority and local opposition.[9]

In the EU, energy policy – a shared competence between the EU and its member states – is similarly multi-layered. The European Commission sets strategic priorities, but national governments retain autonomy over how these policies are implemented domestically. National regulatory authorities (NRAs) in each member state are responsible for implementing EU energy law and ensuring market compliance at the national level. The Agency for the Cooperation of Energy Regulators (ACER) plays a coordinating role, supporting NRAs and promoting cross-border market integration and infrastructure planning. For example, ACER advises on the implementation of the 2023 EU Action Plan for Grids, which aims to accelerate grid modernisation and enhance interconnectivity.

Long-term grid planning is governed by the Trans-European Networks for Energy (TEN-E) Regulation, a policy framework aimed at strengthening cross-border energy infrastructure. Planning is guided by a ten-year, non-binding network development plan (TYNDP) created by ENTSO-E, the European association of electricity transmission system operators (TSOs). The process faces criticism for being slow, outdated, and lacking a robust needs-based and cost-benefit methodology, with proposed investments falling short of actual requirements.[10] As in the United States, grid expansion is delayed by lengthy permitting – often taking over five years – due to complex cross-border procedures, limited administrative capacity and local opposition.[11]

As a result, there is a growing queue of renewable generation and storage projects awaiting grid interconnection. A 2023 study by Lawrence Berkeley National Laboratory found that nearly 2,600 gigawatts (GW) of proposed generation and storage capacity were actively seeking grid interconnection in the United States.[12] In Europe, a report from Beyond Fossil Fuels, Ember, E3G and the Institute for Energy Economics and Financial Analysis found that 1,700 GW of renewable energy and hybrid projects were waiting for grid connections across 16 countries in 2024-2025.[13]

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[8] Sonal Patel, "Out of Sync: The Infrastructure Misalignment Undermining the U.S. Grid", in *POWER Magazine*, 11 June 2025, https://www.powermag.com/?p=235272.

[9] Ibid.

[10] Saša Butorac, "EU Electricity Grids", in *EPRS Briefings*, May 2025, https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2025)772854.

[11] Ibid.

[12] Berkeley Lab, *Grid Connection Backlog Grows by 30% in 2023, Dominated by Requests for Solar, Wind, and Energy Storage*, 10 April 2024, https://emp.lbl.gov/news/grid-connection-backlog-grows-30-2023-dominated-requests-solar-wind-and-energy-storage.

[13] Beyond Fossil Fuels (BFF) et al., *How Europe's Grid Operators Are Preparing for the Energy Transition. A Snapshot of Electricity Transmission System Operator Practices and Plans*, May 2025,

The United States is also going through other policy shifts that impact domestic developments and international cooperation. Recent national security trade investigations, conducted under Section 232 of the Trade Expansion Act of 1962, have placed 50 per cent tariffs on steel and aluminium, the primary components of next generation transmission lines. An ongoing Section 232 investigation into semiconductors and derivative products could further disrupt the supply of critical components for grid infrastructure. Simultaneously, funding for research and development, including programmes backed by the Inflation Reduction Act (IRA), is being scaled back or eliminated. Over the past two decades, US energy policy has swung with the political tide, especially on decarbonisation – creating uncertainty around the long-term direction and durability of regulatory actions.

With the United States and Europe focused on different goals, transatlantic collaboration on energy policy appears increasingly fragmented. However, growing energy demands and rising competition from Chinese state-owned manufacturers present shared challenges and opportunities that both sides will need to address together to effectively de-risk their energy infrastructure.

2. Rising electricity needs

(Geo)political tensions notwithstanding, electrification and energy-intensive digital technologies will create additional demands on legacy grids.[14] In 2024, there were over 8,500 data centres globally, with about 33 per cent of these located in the United States, 16 per cent in Europe and close to 10 per cent in China.[15] Demand for AI will double data centres' electricity consumption from 2024 to 2026.[16] New strategic manufacturing plans, particularly for semiconductor and battery production, will also be critical drivers of electricity.[17]

In the coming years, US and European electricity demand is projected to increase significantly also due to the electrification of various sectors, including transportation and residential heating and cooling.[18] According to the US Energy Information Administration (EIA), total electricity demand in the United States is expected to grow by approximately 2 per cent annually, bolstered by factors such as the adoption of electric vehicles (EVs) and the increasing installation of heat

https://beyondfossilfuels.org/?p=91684.

[14] International Energy Agency (IEA), *Electricity 2025. Analysis and Forecast to 2027*, February 2025, https://www.iea.org/reports/electricity-2025.

[15] Cloudscene website: Cloudscene Leaderboard, https://cloudscene.com/rankings/leaderboard.

[16] IEA, *Electricity 2024. Analysis and Forecast to 2026*, January 2024, https://www.iea.org/reports/electricity-2024.

[17] Cy McGeady, Hatley Post and Jane Nakano, "Energy Considerations at the Dawn of Strategic Manufacturing", in *CSIS Commentaries*, 19 April 2024, https://www.csis.org/node/110269.

[18] IEA, *Electricity 2025*, cit.

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pumps for more efficient home heating.[19] The International Energy Agency (IEA) indicated that EU electricity consumption grew by 1.4 per cent in 2024 as various sectors adapt to new energy conditions, effectively marking a turnaround after two consecutive years of decline.[20]

While the United States is largely energy independent – drawing on a mix of fossil fuels, renewables and nuclear power – Europe faces a more delicate balancing act. It must contend with rising electricity demand while bolstering resilience against price volatility and energy security risks, particularly as it accelerates efforts to diversify away from Russian gas in a shifting geopolitical landscape.

Renewable energy sources, particularly wind and solar, are increasingly positioned to meet a substantial share of rising electricity demand on both sides of the Atlantic. Renewable energy is price competitive, affordable and faster and easier to deploy than traditional infrastructure such as nuclear power plants or long-distance pipelines.[21] In the EU, this transition is being driven by a binding target to source at least 42.5 per cent of final energy consumption from renewables by 2030, with an aspirational goal of 45 per cent.[22] Meeting this target will require investments in renewable generation and grid modernisation. Similarly, in the United States, solar and wind now account for the majority of new capacity additions.[23] According to the EIA, wind power capacity in the United States more than tripled between 2010 and 2022.[24] Solar power grew even faster, increasing 46 times over the same period.[25] In the EU, wind and solar power generation increased more than fivefold between 2009 and 2023, rising from 139 TWh to 721 TWh.[26] During the same period, their share of the EU's electricity mix grew from 5 per cent to 27 per cent.[27]

As both regions increasingly adopt clean energy technologies, grids must evolve to accommodate a growing share of variable energy sources. This requires the expansion and modernisation of grid infrastructure, as well as the scaling-up of storage capacities.

[19] EIA, *EIA Extends Five Key Energy Forecasts through December 2026*, 15 January 2025, https://www.eia.gov/todayinenergy/detail.php?id=64264.

[20] IEA, *Electricity 2025*, cit.

[21] International Renewable Energy Agency (IRENA), *Renewable Power Generation Costs in 2023*, September 2024, https://www.irena.org/Publications/2024/Sep/Renewable-Power-Generation-Costs-in-2023.

[22] European Commission DG for Energy website: *Renewable Energy Targets*, https://energy.ec.europa.eu/node/5600_en.

[23] Federal Energy Regulatory Commission (FERC), *Energy Infrastructure Update for March 2025*, 12 May 2025, https://cms.ferc.gov/media/39324.

[24] EIA, *International Energy Outlook 2023 with Projections to 2050*, 11 October 2023, https://www.eia.gov/outlooks/ieo/pdf/IEO2023_Release_Presentation.pdf.

[25] Ibid.

[26] Ember, *European Electricity Review 2024*, 7 February 2024, https://ember-energy.org/?p=3621.

[27] Ibid.

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3. Assessing critical infrastructure

The grid challenges outlined above cannot be solved with yesterday's technology. As the United States and Europe pursue parallel efforts to modernise their electrical grids – integrating renewable energy, expanding storage capacity and deploying smart technologies – they are increasingly turning to next-generation solutions to boost capacity, enhance resilience and enable more dynamic, decentralised electricity systems.

The adoption of new grid technologies brings with it a new set of security challenges for this critical infrastructure. While diversification to renewables and the digitalisation of grid systems are essential for long-term energy security, they also create dependencies in global supply chains and expose countries to technologies produced in nations that are strategic competitors or non-aligned.

Cybersecurity risks for critical infrastructure remain a top concern for intelligence agencies. In 2024, the "Five Eyes" intelligence agencies issued a joint warning to governments and businesses about the continued efforts of hostile state actors to infiltrate critical infrastructure.[28] The alert specifically highlighted the activities of Volt Typhoon, a Chinese state-sponsored hacking group. By pre-positioning themselves on US and European systems, hostile actors may disrupt or degrade critical infrastructure operations during periods of crisis or conflict. Utilities are essential service providers to the broader economy and are an attractive target. Cybersecurity has long been an industry priority, but the growing interdependence of cross-border power systems – coupled with the rising sophistication of cyberattacks – has significantly complicated both governance and crisis response.[29]

Beyond external cyberattacks, the growing presence of Chinese state-linked firms in key segments of the grid supply chain and infrastructure raises strategic concerns on both sides of the Atlantic. China has been investing heavily in its transmission grid infrastructure to keep up with its boom in renewables.[30] In 2025 alone, State Grid Corporation of China (SGCC) announced that it would invest over 88.7 billion US dollars (650 billion yuan) into its power network (up from 600 billion yuan in 2024).[31] By comparison, in 2024, the US government invested 7 billion US dollars in

[28] US Cybersecurity and Infrastructure Security Agency (CISA), *PRC State-Sponsored Actors Compromise and Maintain Persistent Access to U.S. Critical Infrastructure*, 7 February 2024, https://www.cisa.gov/news-events/cybersecurity-advisories/aa24-038a.

[29] Spencer Feingold and Filipe Beato, "Iberian Blackout: Cyberattack Is Not to Blame – But the Threat to Power Grids Is Real. Here's Why", in *World Economic Forum Articles*, 1 May 2025, https://www.weforum.org/stories/2025/05/spain-might-not-cyberattack-blackout-power-outage-electric-grids-vulnerable.

[30] "China Accelerates Grid Spending to Absorb Deluge of Solar Power," in *Bloomberg*, cit.

[31] "China's State Grid Outlays Record $88.7 bln Investment for 2025", in *Reuters*, 15 January 2025, https://www.reuters.com/business/energy/chinas-state-grid-outlays-record-887-bln-investment-2025-2025-01-15.

IRA-linked funds in the grid,[32] while privately held companies spent 34 billion US dollars on grid technologies and transmission.[33] Beijing views a robust grid as key to energy security and economic growth and is rapidly closing technology gaps. As part of this effort, China continues to expand its network of ultra-high voltage (UHV) transmission lines to move electricity efficiently across vast distances and balance regional supply and demand.[34]

China's ambitions do not stop at its borders. The PRC has made strategic Belt and Road investments in energy infrastructure across Asia, Africa, Europe and Latin America.[35] Under the Global Energy Interconnection (GEI) initiative announced by President Xi Jinping in 2015, China envisions a globally interconnected electricity network designed to transmit renewable energy across continents.[36] Opportunities to supply the rest of the world are enormous, with 85 per cent of new energy demand in the coming years expected to come from outside the developed world.[37] Chinese equipment (from transformers to smart meters) is widely used globally, raising supply chain security questions for the United States and EU.

The grid technology stack includes hardware like inverters, transformers and storage systems; software and data networks that support smart grid functionality; and the ownership and control structures that govern infrastructure development. Four critical areas create vulnerabilities within the US and European grid systems: (1) the supply and deployment of inverters and transformers, (2) grid energy storage systems, (3) smart grid technologies and associated data networks and (4) Chinese ownership or investment in electricity infrastructure.

Vulnerabilities exist in two main ways: the devices can be controlled or manipulated remotely by hostile actors, or the devices may be disabled due to parts or supplies that are not readily available.

3.1 The supply and deployment of inverters and transformers

As the United States and Europe accelerate the integration of renewable energy sources, power inverters convert the output of solar panels or battery storage

[32] US Department of Energy, *2024 Wrap-Up: Advancing a More Powerful Grid*, 19 December 2024, https://www.energy.gov/node/4847253.

[33] Edison Electric Institute website: *Industry Data*, https://www.eei.org/en/resources-and-media/industry-data.

[34] Xiaoying You, "'A Bullet Train for Power': China's Ultra-High-Voltage Electricity Grid", in *BBC News*, 15 November 2024, https://www.bbc.com/future/article/20241113-will-chinas-ultra-high-voltage-grid-pay-off-for-renewable-power.

[35] Fiona Quimbre et al., *China's Global Energy Interconnection. Exploring the Security Implications of a Power Grid Developed and Governed by China*, Santa Monica, RAND, December 2023, https://www.rand.org/pubs/research_reports/RRA2490-1.html.

[36] Ibid.

[37] Marco Arcelli, "The Opportunity of Meeting Energy Demand in the Global South", in *World Economic Forum Articles*, 2 May 2024, https://www.weforum.org/stories/2024/05/opportunity-servicing-energy-demand-global-south.

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systems into alternating current (AC) synchronised with the grid. Inverters typically include network connectivity to facilitate remote diagnostics, firmware updates and performance optimisation. This connectivity also introduces significant cybersecurity risk via attacks or control by hostile actors.

Inverters sit at critical nodes in the power system, and their coordinated failure could destabilise grid operations. A substantial share of the global inverter market is dominated by Chinese manufacturers.[38] Concerns have emerged that these devices could contain embedded vulnerabilities that might be exploited to disrupt grid operations. A May 2025 Reuters report reported that US security researchers discovered undocumented communication devices embedded within Chinese-manufactured solar inverters used in grid applications.[39] Experts noted that such hardware could allow actors to override local controls, disable equipment, or alter operational settings.[40]

Beyond inverters, transformers are also essential, long-life components of the transmission grid and difficult to replace quickly in the event of failure or sabotage. China is the world's largest exporter of electrical transformers.[41] In 2019, the United States seized a Chinese-manufactured transformer intended for use in Colorado over cybersecurity concerns.[42] The transformer was sent to Sandia National Laboratories for examination. While the reasons for the seizure and the results of the examination were not public, the incident underscored the strategic sensitivity of these assets and attempts to remotely manipulate their operation.

3.2 Grid energy storage systems

Energy storage technologies store surplus power when demand is low and release it during peak times. Utility-scale energy storage systems (ESS) bank electricity into batteries for later use or convert it into other energy forms. ESS are becoming key to the modernisation of electrical grids, particularly in the context of variable renewable energy sources such as solar and wind power. Unlike conventional fossil fuel-based generation, variable renewable energy sources are inherently intermittent (they do not produce power continuously) and non-dispatchable, leading to temporal mismatches between supply and demand. ESS, particularly

[38] Wood Mackenzie, *Top 10 Solar PV Inverter Vendors Account for 86% of Global Market Share*, 14 August 2023, https://www.woodmac.com/press-releases/top-10-solar-pv-inverter-vendors-account-for-86-of-global-market-share.

[39] Sarah Mcfarlane, "Rogue Communication Devices Found in Chinese Solar Power Inverters", in *Reuters*, 14 May 2025, https://www.reuters.com/sustainability/climate-energy/ghost-machine-rogue-communication-devices-found-chinese-inverters-2025-05-14.

[40] Ibid.

[41] Observatory of Economic Complexity (OEC) website: *Electrical Transformers*, https://oec.world/en/profile/hs/electrical-transformers.

[42] Rebecca Smith, "U.S. Seizure of Chinese-Built Transformer Raises Specter of Closer Scrutiny", in *The Wall Street Journal*, 27 May 2020, https://www.wsj.com/articles/u-s-seizure-of-chinese-built-transformer-raises-specter-of-closer-scrutiny-11590598710.

battery energy storage systems (BESS), play an important role in addressing these challenges and can help ease transmission congestion, deferring or eliminating the need for costly upgrades to grid infrastructure.

China currently dominates the global supply chain for lithium-ion batteries, which constitute most deployed grid-scale storage systems. According to the IEA, China is responsible for approximately 85 per cent of global lithium-ion battery cell production capacity by monetary value.[43] In 2022, China produced 85 per cent of the world's anodes, 82 per cent of electrolytes, 74 per cent of separators and 70 per cent of cathodes.[44] The PRC processes over 90 per cent of the world's graphite.[45] In 2022, Chinese companies accounted for over two-thirds of the world's processing capacity for cobalt and lithium, two critical materials for battery production.[46]

This concentration of supply chain capacity presents strategic risks, exposing other nations to disruptions arising from geopolitical tensions, trade restrictions, or domestic policy shifts within China. The recent restrictions placed by China on specific raw materials needed to produce automobile batteries brought supply chain vulnerabilities into sharp focus.[47] China's dominance may also lead to market distortions and price volatility, hindering the ability of other countries to deploy storage at scale. It also positions Beijing to shape global standards in ways that may not align with other nations' strategic or environmental priorities.

Compounding these supply chain concerns, the aforementioned May 2025 Reuters report revealed that some Chinese-manufactured battery systems in the United States equally contained undocumented communication modules, raising alarms about the potential for remote manipulation.[48]

3.3 Smart grid technologies and data networks

Smart grids integrate advanced digital communication, automation and control technologies into the conventional grid to enable better energy management. These technologies support the two-way flow of electricity and information between utilities and consumers, facilitate the integration of renewable energy sources and enhance the overall operational intelligence of the grid.

Common smart grid technologies include advanced metering infrastructure (AMI), supervisory control and data acquisition (SCADA) systems, phasor measurement

[43] IEA, *Batteries and Secure Energy Transitions*, April 2024, https://www.iea.org/reports/batteries-and-secure-energy-transitions.

[44] EIA, *China Dominates Global Trade of Battery Minerals*, 21 May 2025, https://www.eia.gov/todayinenergy/detail.php?id=65305.

[45] Ibid.

[46] Ibid.

[47] Ibid.

[48] Sarah Mcfarlane, "Rogue Communication Devices Found in Chinese Solar Power Inverters", cit.

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units (PMUs), demand response management (DRM), advanced distribution management systems (ADMS), distributed energy resources management systems (DERMS) and vehicle-to-grid (V2G) technologies. Both the hardware and software to operate these cutting-edge systems can introduce security vulnerabilities.

The UK's cross-party Coalition on Secure Technology has raised concerns about foreign dependencies in this context, specifically calling on the British government to boost domestic manufacturing of cellular radio modules, which are critical for connecting Internet of Things (IoT) devices. According to the Coalition, three Chinese companies currently control over 50 per cent of the global market for these modules – components that are widely embedded in smart meters, edge devices and other grid-connected equipment.[49] The integration of these components has raised concerns about data transmission and remote control capabilities.

A precedent for such concerns can be found in a recent case uncovered by cybersecurity firm Dragos. According to Dragos' report, the Volt Typhoon group maintained unauthorised access to the operational technology network of Littleton Electric Light and Water Departments in Massachusetts for nearly nine months (from February to November 2024).[50]

At the centre of the threat matrix are communication networks. One prominent concern has been Huawei, the Chinese tech giant known for telecommunications gear, which also sells industrial network equipment and has developed solutions for smart grids. Huawei's involvement in smart grid infrastructure has prompted security concerns due to obligations under Chinese law for firms to cooperate with state intelligence agencies.[51]

As a result, Huawei has been subject to increasing restrictions. The United States has banned Huawei from federal telecommunications networks and barred its involvement in critical infrastructure sectors, including energy.[52] In Europe, several countries have followed suit: the UK excluded Huawei from its 5G networks and has taken steps to remove its technology from smart grid pilot programmes.[53] Germany announced in 2023 that it would phase out Chinese components from

[49] Lucy Fisher, "Chinese Components in 'Smart' Devices Pose Sabotage Threat to UK, MP Warns", in *Financial Times*, 20 February 2025, https://www.ft.com/content/518e6b5d-068a-4375-a625-87d8c5b422a1.

[50] Keenan Bassma, "Notorious Chinese Hacking Company Went Nearly a Year Undetected in Littleton Utility Company", in *Boston 25 News*, 13 March 2025, https://www.boston25news.com/news/local/notorious-chinese-hacking-company-went-nearly-year-undetected-littleton-utility-company/BBEQYUB5AJFZFPMBD343EN2SEY.

[51] "EU Must Be Aware of China's Intelligence Law when Drawing up 5G Rules", in *Reuters*, 19 July 2019, https://www.reuters.com/article/technology/eu-must-be-aware-of-chinas-intelligence-law-when-drawing-up-5g-rules-king-idUSKCN1UE193.

[52] "U.S. Actions Against China's Huawei", in *Reuters*, last accessed 20 June 2025, https://www.reuters.com/graphics/USA-CHINA/HUAWEI-TIMELINE/zgvomxwlgvd.

[53] UK Government, *Huawei to Be Removed from UK 5G Networks by 2027*, 14 July 2020, https://www.gov.uk/government/news/huawei-to-be-removed-from-uk-5g-networks-by-2027.

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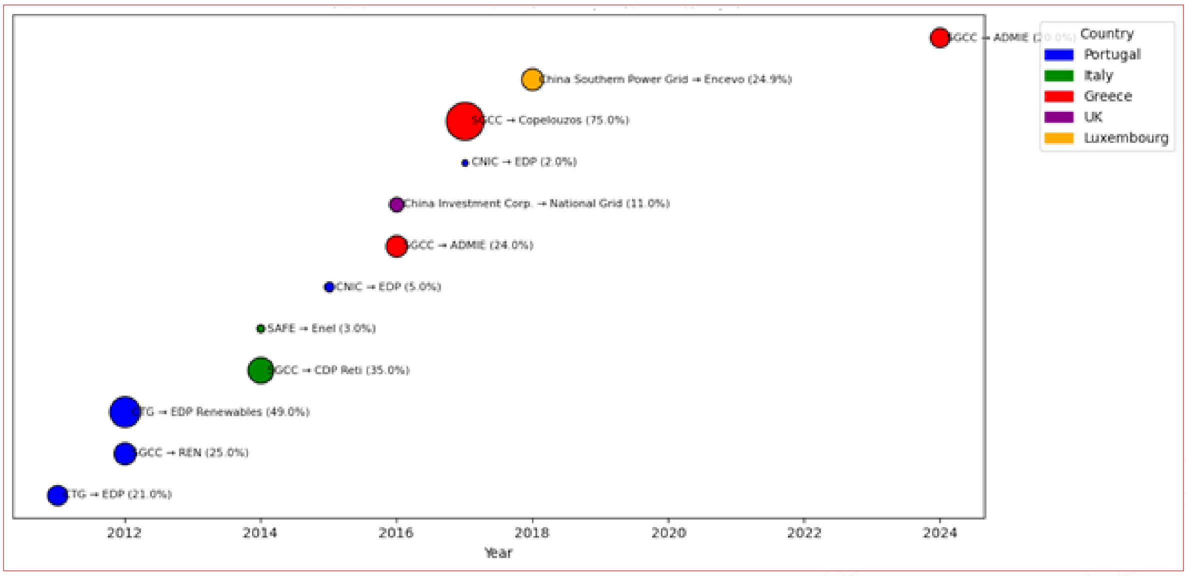
critical energy and telecommunication systems by 2026.[54] Similar scrutiny has emerged in other European countries, where regulators have discouraged the use of Huawei gear in grid communication backbones.[55]

3.4 Chinese direct ownership and investment in electricity infrastructure

According to the American Enterprise Institute's China Global Investment Tracker, Chinese entities invested 1.49 trillion US dollars globally between 2005 and 2024, with 464.86 billion US dollars (31 per cent) directed toward the energy sector.[56] While US regulations limit Chinese ownership of electricity infrastructure, Chinese investment is more prominent in Europe, especially in Southern countries affected by the 2010s economic crises.

Figure 1 | Timeline of Chinese investments in European energy grid sector (2011-24)



SGCC is the most active investor, acquiring major stakes in national grid operators:[57]

- Portugal: 25 per cent of REN (2012–2014);
- Italy: 35 per cent of CDP Reti (2014), which holds shares in Terna and Snam;
- Greece: 24 per cent of ADMIE (2016), increased to 44 per cent in 2024; also acquired 75 per cent of Copelouzos (2017).

[54] "Germany to Phase out Huawei, ZTE Components from Its 5G Core Network", in *Reuters*, 11 July 2024, https://www.reuters.com/business/media-telecom/germany-agrees-phaseout-huawei-zte-components-5g-core-network-2024-07-11.

[55] Cynthia Kroet, "Eleven EU Countries Took 5G Security Measures to Ban Huawei, ZTE", in *Euronews*, 12 August 2024, https://www.euronews.com/next/2024/08/12/eleven-eu-countries-took-5g-security-measures-to-ban-huawei-zte.

[56] American Enterprise Institute website: *China Global Investment Tracker*, https://www.aei.org/?p=830737.

[57] Nicolas Mazzucchi, "China and European Electricity Networks: Strategy and Issues", *FRS Notes*, No. 17/2018 (12 September 2018), https://www.frstrategie.org/en/node/92.

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China Three Gorges Corporation (CTG) holds a 21 per cent stake in Portugal's EDP.[58] China Southern Power Grid entered Europe in 2018 with a 24.9 per cent stake in Luxembourg's Encevo.[59]

Other notable investments include:[60]

- SAFE's 3 per cent stake in Italy's Enel (2014);
- China Investment Corp.'s 11 per cent stake in the UK's grid (2016);
- CNIC's 5 per cent stake in EDP, raised to 7 per cent by 2017.

Several attempted acquisitions were blocked, including in Belgium (Eandis), Spain (REE) and Germany (50Hertz).[61]

These investments give Chinese entities influence over energy governance and access to sensitive grid data and policy forums, particularly through their participation in entities like ENTSO-E.

4. Policy recommendations: Enhancing US-EU cooperation for grid security

As the governments continue their individual work to strengthen their grids, and regardless of their different opinions on decarbonisation and renewables, transmission technologies and grid security should remain a focus of future transatlantic dialogues due to the shared opportunities and challenges. Similarly, this work should also be addressed in the ongoing US-UK Technology Agreement, agreed by leaders on 8 May 2025.

In the past, the US-EU Energy Council served as the primary platform for transatlantic coordination on energy security and infrastructure resilience, with grid modernisation, cybersecurity and the integration of renewables included in discussions over the life of the Council. The Trade and Technology Council (TTC) also included discussions on the importance of energy security, aligning standards and screening mechanisms to reduce dependency on high-risk vendors, including those from China, and coordination on challenges associated with incorporating more clean energy into power grids.[62]

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[58] EDP, *EDP and China Three Gorges Establish Strategic Partnership*, 22 December 2011, https://www.edp.com/en/node/146376.

[59] Nicolas Mazzucchi, "China and European Electricity Networks", cit.

[60] Ibid.

[61] Ibid.

[62] Trade and Technology Council (TTC), *Joint Statement EU-US Trade and Technology Council of 4-5 April 2024 in Leuven, Belgium*, 5 April 2024, https://ec.europa.eu/commission/presscorner/detail/en/statement_24_1828.

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Despite these efforts, more work remains to be done. To address the growing challenge posed by Chinese dominance in power grid and transmission technologies and their supply chains, the United States and the Europe must adopt a coordinated set of policy and procurement strategies. The speed and scale of China's manufacturing capabilities, which has been evident in clean technologies such as solar power, requires transatlantic cooperation. Together, the transatlantic partners can reinforce transatlantic economic security and competitiveness.

Below are a series of policy recommendations:

1) *Prioritise transatlantic grid security and innovation*: The United States and EU and/or the United States and UK should launch a process focused on securing and modernising their electricity grids while maintaining domestic industrial capabilities. This initiative would prioritise:

- Shared cybersecurity collaboration to protect critical infrastructure from foreign interference.
- Joint R&D on advanced grid technologies, including AI-driven grid management, long-duration energy storage and high-voltage direct current (HVDC) systems.
- Shared threat intelligence and resilience planning to address vulnerabilities in transmission networks.

This process could be housed under a re-launched US-EU Energy Council or similar structure that the transatlantic partners establish.

2) *Leverage strategic procurement to exclude high-risk vendors*: Both sides should adopt procurement policies that prioritise trusted vendors and explicitly exclude suppliers linked to authoritarian regimes or those failing to meet transparency and security benchmarks. Key actions include:

- Creating a joint "trusted vendor" list for public procurement in grid infrastructure.
- Mandating security and origin disclosures in all bids for transmission projects.
- Using trade defence and anti-coercion instruments to counter predatory pricing by Chinese state-backed firms.
- Share intelligence concerning Chinese vendors and suspected vulnerabilities and ensure that this information is considered as the US and Europe countries screen inward investment in the electricity transmission sector.

These approaches mirror successful strategies in the telecom sector and would help prevent China from undercutting Western firms through subsidised bids.

3) *Strengthen Transatlantic supply chains for grid components*: To support the transatlantic supply chains, the US and EU should support domestic and allied production of critical grid components such as semiconductors, rare earth magnets and power electronics. This support could include:

- Joint industrial initiative to fund research and development as well as strategic manufacturing hubs in both regions.

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- Using trade agreements as incentives for reshoring and nearshoring of key supply chain segments, including agreements that exempt these products from tariffs.
- Coordination to secure raw materials from trusted partners who are also committed to economic and energy security.

Such efforts would enhance supply chain resilience while creating high-value jobs on both sides of the Atlantic.

4) *Align standards and certification for grid technologies*: To reduce dependency on Chinese suppliers and accelerate deployment of trusted alternatives, the United States and Europe should harmonise technical standards and certification processes for grid components. This includes:

- Mutual recognition of testing and safety protocols for transformers, smart meters and control systems.
- Joint development of interoperability standards for digital grid platforms and renewable integration.
- Developing aligned cybersecurity protocols and information-sharing mechanisms for grid infrastructure could improve the ability of both regions to prevent, detect and respond to cyber or hybrid threats.

Such alignment would create a larger, unified market for transatlantic manufacturers, lowering costs and increasing competitiveness against Chinese firms. Joint standards would also provide commercial clarity in third-country markets.

Conclusion

A coordinated US-EU approach to grid and transmission technology represents a strategic pathway within the de-risking framework. Cooperation could not only strengthen grid resilience but could also help foster competitiveness, reduce reliance on rivals, secure supply chains, drive innovation and create jobs. Together, the United States and Europe can chart an effective course out of gridlock.

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Appendix

Table 1 | The US and European grids systems

Category	United States	Europe
Grid structure	The US electrical grid is segmented into three major interconnections – the Eastern, Western and Texas (ERCOT) Interconnections – which operate largely independently. These systems rely on AC, allowing for voltage levels to be easily stepped up or down using transformers in substations. A limited number of HVDC transmission lines link the three Interconnections. HVDC lines transmit power over long distances with higher efficiency and lower energy losses than AC systems but represent only a small fraction of total US grid capacity.	Europe is organised into several synchronous areas, the largest being CESA. Ukraine and Moldova synchronised their electricity grids with CESA in 2022.[63] Estonia, Latvia and Lithuania synchronised with CESA in February 2025.[64] Other areas include the Nordic (Sweden, Norway, Finland and eastern Denmark), British and Irish grids, interconnected via HVDC links.
Transmission technology	The United States has ~700,000 circuit miles of transmission lines (typically made from aluminium, steel or a combination of both materials). Lines can be high voltage (HV), extra-high voltage (EHV) and UHV lines. UHV lines are rare but valuable for long-distance, low-loss transmission.	The EU grid spans ~11 million kilometres, with 97 per cent being distribution networks. HVDC links are used for asynchronous energy exchange between synchronous areas.
Ownership models	Grids and transmission lines are owned by a mix of investor-owned utilities (IOUs, serving 72 per cent of electricity customers), publicly owned utilities (POUs, serving 15 per cent) and electric cooperatives (serving 12 per cent). IOUs are for-profit; POUs and co-ops are not-for-profit. Ownership affects investment strategies and risk tolerance.	TSOs are responsible for high-voltage networks and cross-border infrastructure. Distribution system operators (DSOs) oversee medium- and low-voltage networks. National TSOs are typically state-owned or publicly regulated monopolies (e.g., RTE in France, TenneT in the Netherlands and Germany, and Terna in Italy). DSOs may be public, private, or municipal. Liberalised markets exist for generation and retail, with

[63] ENTSO-E, *Continental Europe Successful Synchronisation with Ukraine and Moldova Power Systems*, 16 March 2022, https://www.entsoe.eu/news/2022/03/16/continental-europe-successful-synchronisation-with-ukraine-and-moldova-power-systems.

[64] ENTSO-E, *ENTSO-E Confirms Successful Synchronization of the Continental European Electricity System with the Systems of the Baltic Countries*, 9 February 2025, https://www.entsoe.eu/news/2025/02/09/entso-e-confirms-successful-synchronization-of-the-continental-european-electricity-system-with-the-systems-of-the-baltic-countries.

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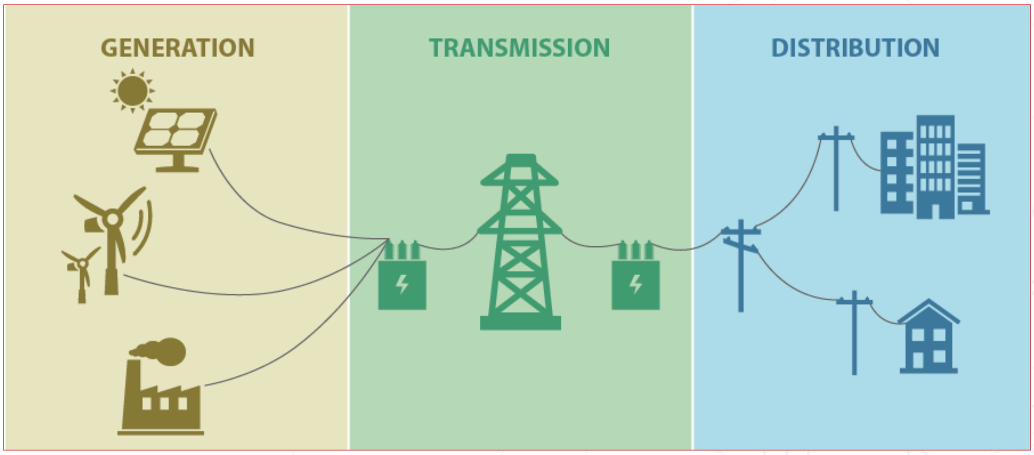
		companies such as EDF, Enel, Iberdrola and E.ON.
Regulatory bodies	FERC oversees transmission rates and services, authorises the placement of new interstate transmission lines and reviews utility mergers and acquisitions. State-level PUCs regulate rates. Grid operations are managed by ISOs within a single state and by RTOs across multiple states. These entities balance electricity supply and demand in real time, coordinate regional transmission and distribution networks, and determine fixed rates of return for transmission use.	ENTSO-E coordinates 40 TSOs across 36 countries, including EU member states as well as several non-EU countries such as the UK, Switzerland and Türkiye. NRAs oversee national TSOs and DSOs. At the EU level, ACER coordinates between NRAs and monitors cross-border markets.
Investment mechanisms	Utilities recover costs through ratepayer tariffs approved by PUCs. IOUs raise capital via public markets; POUs use tax-exempt bonds; co-ops rely on federal programmes. Federal support includes the Infrastructure Investment and Jobs Act (IIJA) and IRA.	Grid development is funded through tariffs, national public funding and EU-level instruments like the Connecting Europe Facility for Energy (CEF-E). TSOs issue bonds; smaller DSOs use bank loans.
Market structure	Deregulation in the 1990s ended vertical integration. Most transmission remains under regulated monopolies, though competitive markets exist in some regions.	Electricity generation and retail are liberalised. TSOs and DSOs operate as regulated monopolies, with unbundling required to separate network operations from generation/supply.

Figure 2 | Simplified schematic of electric power sector systems



Source: Ashley J. Lawson, "Introduction to Electricity Transmission", in *CRS In Focus*, No. IF12253 (18 November 2022), https://www.congress.gov/crs-product/IF12253.

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List of acronyms

ACER	Agency for the Cooperation of Energy Regulators
ADMIE	Greece Independent Power Transmission Operator
ADMS	Advanced distribution management system
AI	Artificial intelligence
AMI	Advanced metering infrastructure
BESS	Battery energy storage system
CEF-E	Connecting Europe Facility for Energy
CESA	Continental Europe Synchronous Area
CGT	China Three Gorges Corporation
DERMS	Distributed energy resources management system
DRM	Demand response management
DSO	Distribution system operator
EDP	Energias de Portugal
EHV	Extra-high voltage
EIA	US Energy Information Administration
ENTSO-E	European Network of Transmission System Operators for Electricity
ERCOT	Electric Reliability Council of Texas
ESS	Energy storage system
EU	European Union
EV	Electric vehicle
FERC	Federal Energy Regulatory Commission
GEI	Global Energy Interconnection
GW	Gigawatt
HV	High voltage
HVDC	High-voltage direct current
IEA	International Energy Agency
IIJA	Infrastructure Investment and Jobs Act
IRA	Inflation Reduction Act
ISO	Independent system operator
IUO	Investor-owned utility
NRA	National regulatory authority
PMU	Phasor measurement unit
POU	Publicly owned utility
PRC	People's Republic of China
PUC	Public utility commission
R&D	Research and development
REE	Red Eléctrica de España
REN	Redes Energéticas Nacionais
RTO	Regional transmission organisation
SCADA	Supervisory control and data acquisition
SGCC	State Grid Corporation of China
TEN-E	Trans-European Networks for Energy
TSO	Electricity transmission system operator
TWh	Terawatt hour

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TTC	Trade and Technology Council
TYNDP	10-year network development plan
UHV	Ultra-high voltage
UK	United Kingdom
V2G	Vehicle-to-grid

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