clean
technology
partnerships
initiative

A geoeconomic strategy for Europe

Building clean technology partnerships

July 2026

Executive Summary

Europe has lived through two decades of rolling shocks – the 2008 financial crisis, the COVID pandemic, the war in Ukraine, and now the Middle East. Each was met with emergency measures that faded as prices stabilised, but together they mark a shift from integration and predictability to great-power competition, leverage over trading partners, and recurring supply shocks.

The energy transition surfaces a new vulnerability: concentrated clean tech supply chains, often overwhelmingly in China. The US is retreating from some clean technologies and no longer treats Europe as an essential partner, while high energy costs, scarce resources, and stretched finances narrow Europe's options.

Europe is better placed here than in past fossil fuel shocks – it can produce more energy at home and holds real expertise across clean technologies. But closing today's gaps and tomorrow's bottlenecks demands choices that are strategic and comprehensive, not piecemeal or reactive.

Self-sufficiency is neither achievable nor desirable; the goal is smart partnership. Europe should anchor higher-value activities at home and source upstream inputs from trusted partners – balancing dependency, emissions, industry, and affordability without inflating deficits.

The Clean Technology Partnerships Initiative (CTPI) offers a data-driven framework and a concrete plan: eight key technologies and ten priority interventions, anchored by partners like South Korea, Japan, Australia, Canada, and Brazil. An investment of €19-36 billion (roughly half public) would add 10-15% of production capacity in partner countries – modest against Europe's €600 billion+ annual energy spend.

What clean technology partnerships aim to deliver

Clean technology partnerships are designed to build resilient clean energy supply chains and a stronger manufacturing base for Europe by:

Diagnosing vulnerabilities **across the supply chains of core clean energy technologies**, from raw materials through components and assembly to recycling

Prioritising technologies where **economic growth, energy resilience, and national security** priorities converge

Convening technical, financial, and policy expertise to structure transactions and **guide investment decisions**

Structuring partnerships with trusted, like-minded countries across the **full spectrum of transaction models**, from strategic sourcing to equity and technology commitments

Aligning governments and partners around a shared framework, spanning **industrial strategy, trade, energy, climate, and defence**

Analytical effort builds on existing data and industry research to develop a uniform approach to evaluate supply chain risks of key energy technologies

Project approach

1

Define analytical scope

Create a replicable framework to assess market context and vulnerabilities **across supply chain for given clean energy technology**

2

Identify priority technologies

Synthesise **EU/UK strategy documents and stated goals** into a focused shortlist of technologies and supply chains for assessment

3

Convene expert workshops

Engage subject matter experts to validate analytical approach and **address knowledge gaps**

4

Develop insights and perspectives

Map **end-to-end supply chains for key technologies**, assess market dynamics and vulnerabilities, and **identify strategic partnership opportunities**

5

Stakeholder engagement

Engage EU, UK, and other key country partners to validate findings, inform diplomatic and domestic policy, and build coalitions to advance recommendations

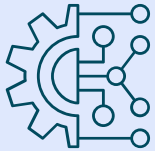
Analytical working group

bruegel · Carnegie Endowment for International Peace · catalyse europe · IEA International Energy Agency · IPPR · Kaya Partners · Mission Possible Partnership · Net Zero Industrial Policy Lab · RMI · Rhodium Group

From the full set of clean energy technologies, our approach evaluates government strategy and applies three lenses to qualify the shortlist

Evaluate global clean technology landscape

Assess government strategy and policy



Identify technology priorities through three lenses

Develop final shortlist of focus technologies

Energy Resilience

Focus

Secure materials and components for a reliable energy system

Goal

Reduce dependence on vulnerable fuel and material imports—ensure reliable access to the technologies, components, and inputs required to operate a secure, affordable clean energy system

National Security

Focus

Build trusted supply of defence-relevant and critical technologies

Goal

Prevent dependence while preserving defence capability and securing trusted supply of critical technologies across jurisdictions

Economic Growth

Focus

Maximise value creation and industrial competitiveness

Goal

Prioritise strengths in manufacturing, innovation, and advanced services for energy technologies—targeting sectors that generate high-quality jobs, export growth, and technological breakthroughs

EU’s government-wide strategies

for manufactured energy technologies and industrial decarbonisation

NOT EXHAUSTIVE

Both · Net-Zero Industry Act · REPowerEU · Focus technologies

Technology	Summary of EU Goals & Objectives
Batteries	Achieve 40% domestic mfg. target for strategic technologies; strengthen EU Battery Regulation sustainability requirements.
Biomethane/Biogas	Expand to 35 bcm by 2030 under REPowerEU to replace fossil gas and reduce Russian import dependence.
CCUS	Develop 50 Mt/yr CO_2 injection capacity by 2030; oil & gas producers expected to add storage targets based on production volumes.
Electric Vehicles	Achieve 90% new car and van fleet CO_2 reduction by 2035 (proposed revision from the original 100% announced in December 2025).
Electrolysers/Hydrogen	Scale electrolyser manufacturing to support 10 Mt domestic renewable hydrogen production by 2030.
Geothermal	Expand geothermal for industrial heat and district heating with near-term goal of clean firm power.
Green Steel	Transition steel sector to EAF and H_2-DRI while maintaining strategic capability; leverage CBAM for demand pull.
Grid Equipment	Execute €584B grid investment this decade for transformers, cables, and HVDC to enable REPowerEU targets.
Heat Pumps	Deploy 30 million units by 2030; expand EU manufacturing capacity (currently 25 GW, 20% global share).
Hydropower/Storage	Maintain and expand hydropower and pumped storage for baseload generation and grid balancing services.
Industrial Decarbonisation	Decarbonise cement, chemicals, and refining via electrification, hydrogen, and CCUS; €1B Innovation Fund heat auction.
Nuclear (incl. SMRs)	Maintain reactor manufacturing and fuel-cycle capabilities; deploy 15 GW SMRs by 2050 via European SMR Alliance.
Solar PV	Deploy 592 GW by 2030; achieve 40% domestic manufacturing despite current <1% cell/wafer production share.
Sustainable Alternative Fuels	Scale e-fuels (e.g., green ammonia, methanol) and SAF production under ReFuelEU Aviation and FuelEU Maritime mandates.
Wind	Deploy 425 GW by 2030 (~100 GW offshore); maintain EU competitive position as net exporter of nacelles.

Source: EU Net-Zero Industry Act; REPowerEU Plan

Prioritising energy technologies with the most supply chain risk

While EU government strategies (Clean Industrial Deal (CID), Net-Zero Industrial Act (NZIA), REPowerEU) address a broad clean technology portfolio, we focus on **seven where supply chain vulnerabilities are most acute and where economic growth, national security, and energy resilience objectives converge.**

These include technologies that already have **mature supply chains with market** concentration (batteries, wind, grid equipment, heat pumps) and technologies where **supply chains are evolving due to reinvestment or new technological deployment** (geothermal, green steel, nuclear).

Batteries enable electric vehicles, grid flexibility, and stationary storage—EU targets 40% domestic manufacturing under NZIA while deploying solar and wind requiring massive storage expansion

Grid equipment underpins renewable deployment, electrification, and cross-border integration—€584B investment needed this decade with **HVDC, transformers, and power electronics** facing 2-5 year lead times

Heat pumps targeted at 30 million units by 2030 under REPowerEU with EU manufacturing capacity expansion (currently 25 GW, 20% global share) to reduce 95% compressor dependence on China

Wind goals of 425 GW by 2030 under REPowerEU; EU maintains competitive position as net exporter of nacelles while addressing rare earth magnets (90%+ China refining) and offshore supply chain gaps

Geothermal offers vast untapped resources for industrial heat and district heating, with limited deployment to date but significant potential as Enhanced Geothermal Systems unlock deep resources across the EU

Green steel underpins decarbonisation of construction, automotive, and wind supply chains but faces 40-50% cost premium vs conventional steel; H_2-DRI technology and scrap recycling offer pathways to maintain competitiveness while cutting emissions

Nuclear critical for baseload power and energy security with focus on conventional fleet life extension and SMRs for 15 GW by 2050 under European SMR Industrial Alliance; HALEU fuel supply diversification priority

Sources: EU Net-Zero Industry Act; IEA Energy Technology Perspectives 2024; IEA Global Hydrogen Review 2025; IEA Renewables 2025; Mission Possible Partnership.

UK’s government-wide strategies

for manufactured energy technologies and industrial decarbonisation

NOT EXHAUSTIVE

Both | 2030 Clean Power Plan | UK Industrial Strategy | Focus technologies

Technology	Summary of Goals & Objectives
Batteries	Develop manufacturing capacity while deploying a projected 115+ GW by 2035 for EVs, grid stability, and defence applications.
Bioenergy/BECCS	Expand sustainable biomass power generation for dispatchable resources and system flexibility.
CCUS	Establish UK as Europe's CO_2 storage hub, enabling industrial decarbonisation.
Charging Infrastructure	Build infrastructure supporting EV transition with smart charging for grid optimisation.
Electric Vehicles	Support North East and West Midlands manufacturing clusters while developing V2G capabilities for grid services.
Geothermal	Explore advanced geothermal systems for district heating and industrial applications to diversify low-carbon heat supply.
Green Ammonia	Position UK in global market for maritime fuel, fertiliser, and hydrogen carrier applications.
Green Steel	Transition steel sector to electric arc/hydrogen production, maintaining "no ready alternative" strategic capability.
Grid Equipment	Execute major investment to reduce 10-15 year connection delays, accelerate historic grid build out, and clean energy deployment.
Heat Pumps	Install 600k units annually by 2028, expanding manufacturing to serve Europe's largest market.
Hydropower/Hydro Storage	Maximise limited UK potential as baseload contribution to renewable energy mix and grid balancing.
Nuclear	Deliver new conventional nuclear and roll out SMR/AMR fleet to establish UK as global leader in nuclear.
Semiconductors	Secure Digital Technologies priority for power electronics in EVs, inverters, and grid management.
Smart Grid/DERs	Deploy smart meters and distributed energy resources to optimise demand flexibility and grid integration.
Solar PV	Deploy 70 GW of solar power to diversify renewable portfolio and capture distributed generation market.
Wind	Deploy 43-50 GW offshore by 2030 as world's second-largest market, unlock onshore deployment, invest in wind manufacturing.

Source: EU Net-Zero Industry Act; REPowerEU Plan

Prioritising energy technologies with the most supply chain risk

While UK government strategies (IS-8, CP2030, GCPA) address a broad clean technology portfolio, we focus on **six areas where supply chain vulnerabilities are most acute and where economic growth, national security, and energy resilience objectives converge.**

These include technologies that already have mature supply chains with **market concentration** (batteries, wind, grids), and technologies where the **supply chain is relatively nascent** in the UK (green ammonia, green steel/iron, nuclear).

Batteries enable electric vehicles, grid flexibility, and stationary storage—projected to increase 5-7X by 2030 under Clean Power Action Plan objectives

Grid equipment critical for 60,000 km in new grid lines by 2030. HVDC, Transformers, and power electronics needed to limit connection-related delays

Wind deployment goals of 70-79 GW for onshore and offshore by 2030 with critical **rare earth elements and permanent magnets** essential to EVs, defence, and power electronics

Green ammonia supports maritime fuel, fertiliser, and hydrogen carrier markets in transformation of chemicals sector

Green steel underpins offshore wind infrastructure, automotive manufacturing, and defence while reducing industrial emissions and dependence on carbon-intensive imports

Nuclear critical for power generation and defence sector with focus **on conventional and AMRs/SMRs for fuel supply and components**

Source: The UK's Modern Industrial Strategy, June 2025; Clean Power 2030 Action Plan: A New Era of Clean Electricity, December 2024

From risk to response

The focus technologies share a diagnosis — concentrated supply chains — but the vulnerability sits in different places: upstream raw materials, engineered inputs, and final manufacturing.

No single response fits them all. Full re-shoring is unaffordable and slow; relying on imports leaves the dependency intact. Smart partnership means matching the instrument to the gap.

The degree of control required differs too — from securing supply on long-term contracts, to co-investing alongside partners, to owning capacity outright.

What follows is the toolkit: five partnership models spanning that spectrum, and the lenses that determine which chains to act on first — and with whom.

Five partnership models for clean technology from FDI to binding offtake agreements

Models	Summary	Rationale	Example Focus Areas
 **Inward Direct Investment**	Foreign companies building manufacturing facilities in-country	Highest domestic impact—creates jobs, tax base, and supply chain anchors; most visible political win	• Battery gigafactories • Wind components manufacturing • Grid equipment manufacturing
 **Strategic Imports**	Long-term procurement agreements for critical materials with diversification requirements	Essential enabler—secures cost-competitive inputs domestic manufacturers require; capital efficient and fast to deploy	• Battery materials (e.g., lithium, graphite) • Primary metals (e.g., copper, aluminium) • Rare earth magnets
 **Strategic Equity Stakes**	Acquiring ownership positions in upstream assets or capacity	Returns flow home; provides pricing visibility and board-level influence over expansion; supports long-term supply security	• Electrolysers raw materials • Battery materials (e.g., graphite, lithium) • Nuclear SMRs
 **Joint Ventures**	Joint ventures or IP licensing pairing domestic technology with partner cost advantages	Monetises IP and retains high-value engineering; but slower to deliver with execution risk on IP protection; JV terms vary	• Green hydrogen / H_2-derived iron • Nuclear SMRs / fuel / components • Specialised materials for dual use (e.g., carbon fibre, alloys)
 **Anchor Offtake Agreements**	Binding purchase commitments that de-risk partner capacity investment	Supports scale-up by guaranteeing demand; but primarily benefits partner—value captured only if offtake feeds domestic industry	• Rare earth magnets • Critical materials (e.g., fluorine, gallium) • Nuclear fuel supply / components (e.g., large castings and forgings)

Sources: IEA; BNEF; S&P Global; RMI; Institute for Progress

Two ways to determine what to invest in and where to partner

Country Selection

How we decide which partners to prioritise

Breadth of supply chain coverage
Countries relevant to multiple archetypes, creating the basis for multi-sector partnerships rather than one-off transactions.

Geopolitical alignment
Partners with existing trade frameworks, DFI presence, or regulatory cooperation with UK/EU.

Demonstrated capability at scale
Named companies, active projects, or proven industrial capacity — not aspirational pipelines. Contractable today.

Complementary partnership models
Resource suppliers, technology co-investors, and infrastructure hosts — ensuring the portfolio spans the full range of deal types.

Supply Chain Sequencing

How we decide which supply chains to act on first

Single-source concentration
What share of production does a single country control, and have they signalled willingness to limit market access?

Irreversibility of delay
Does inaction create permanent strategic disadvantage, or can entry be timed without penalty?

Industrial lead times
How long from commitment to first output? Longer lead times demand earlier sequencing.

Deployment speed
Where two investments have comparable importance, the faster-executing option moves first.

CTPI identified the key supply chain gaps for Europe

Each priority clean tech chain carries a few decisive supply chain gaps and partnership models to strengthen those gaps

Batteries

China-led

KEY GAPS

Anode (natural and synthetic graphite) and cathode (CAM/pCAM)

→ Source cathode and anode production for battery cell manufacturing.

Grid equipment

Long lead times

KEY GAPS

Large power transformers, HVDC converters, electrical steel, copper

→ Korean / Japanese transformer and HVDC plants.

Wind

Imported inputs

KEY GAPS

Rare-earth magnets, subsea export cables

→ Increase capacity for magnet and subsea cable manufacturing through partnerships with key supplying countries.

Green steel

Limited green H2

KEY GAPS

DR-grade iron ore, green HBI/DRI, H2-DRI tech

→ A low-carbon iron (HBI) feedstock partnership.

Nuclear

Russia-exposed

KEY GAPS

Enrichment (SWU), fuel fabrication, HALEU

→ Expand fuel-cycle and enrichment capacity.

Heat pumps

Asia-dependent

KEY GAPS

Compressors, refrigerants, power electronics, copper

→ Secure components and the metals beneath them.

Geothermal

Deployment barriers

KEY GAPS

Drilling rigs and expertise; high-temp alloys and tungsten for turbines and drill rigs

→ Lock in the few specialist inputs early.

Green ammonia

Limited renewable power

KEY GAPS

Green ammonia produced from renewables for fertiliser , chemicals and energy storage

→ Secure low-cost renewable-derived supply and invest in cracking facilities

Go deeper

Each supply chain is mapped in full analytical materials focused on diagnosis and vulnerabilities with illustrative transactions and partner models. *Reach out to the CTPI team for details.*

What it adds up to

Ten partnerships — a modest public outlay for materially lower exposure across critical supply chains.

€19–36B

mobilised across ten transactions

~€9–18B of public capital

~2×

leverage on public funds

roughly half public, half private

10–15%

added production capacity

secured in Europe and among partners

Key partners anchor the portfolio — five of them span multiple chains (not exhaustive)

- **Australia**
- **Brazil**
- **Canada**
- **Japan**
- **South Korea**
- **India**
- **Morocco**
- **Norway**
- **Oman**
- **Zambia**

For context: Europe already invests **€600B** in its energy system every year.
These ten deals are a small share of that — with an outsized impact on resilience and security of supply.

Clean tech partnerships for supply chains can be organised into four primary investment tracks

Track 1

Geopolitical Chokepoints

Supply chains where a single-source produces >70% of global market share and has signalled willingness to limit market access. Delay carries irreversible strategic risk.

Track 2

Strategic Manufacturing

Domestic industrial capabilities that convert Track 1 inputs into transition-critical goods. Long lead times (4–8 years) make early commitment essential.

Track 3

Trusted Partner Capacity Constraints

Segments where trusted suppliers produce the relevant goods, but at a scale insufficient to meet projected demand.

Track 4

Emerging Bottlenecks

Supply chains not dominated by single supply concerns or markets still maturing. Valuable but lower urgency — in some cases, delay improves terms.

Portfolio supply impact summary

Estimated capacity additions and supply outcomes across ten structured transactions, sequenced by strategic priority

Segment	Total Capital	Public Capital	Capacity Invested In	Supply Outcome
Track 1: Geopolitical Chokepoints				
Rare Earths	€1.4–2.8B	€0.9–1.9B	5–10 kt NdPr oxide; domestic NdFeB magnet production	Establishes trusted partner processing and EU magnet manufacturing; reduces single-source vulnerability
Graphite	€735M–1.0B	€450–615M	60–100 kt concentrate (30–65 kt AAM after spheronisation yield)	Creates first EU anode coating capacity; diversifies supply away from near-total Chinese processing
Cathode Active Materials	€2.5–4.5B	€800M–1.5B	100–130 kt/yr CAM across 5 EU nodes (55–75 GWh equivalent)	Builds integrated EU cathode manufacturing for LFP; covers 12–18% of projected domestic demand
Nuclear Enrichment	€3.5–7.0B	€1.5–3.0B	5–10M SWU/yr additional enrichment capacity	Secures fuel supply for conventional and advanced nuclear; eliminates remaining Russian dependency in EU energy system
Track 2: Strategic Manufacturing				
Battery Cells	€3.5–7.0B	€2.0–4.0B	100–200 GWh/yr gigafactory capacity	Scales EU cell production for LFP; reduces reliance on Chinese imports for EV and storage deployment
Green Iron	€1.5–3.0B	€0.9–1.8B	2–4M tpa green HBI for EU steelmaker decarbonisation	Enables cost-competitive green steel; secures low-carbon feedstock from partners
Grid Equipment	€1.0–2.0B	€0.5–1.0B	50–70 GW transformer & switchgear capacity	Expands supplier base and production capacity; eases bottleneck on grid and renewables deployment
Track 3: Trusted Partner Capacity Constraints				
Subsea Cables	€0.9–1.8B	€0.45–0.9B	500–1,000 MVA·km/yr HVDC cable production	Increases domestic production capacity; de-bottlenecks 120 GW+ offshore wind deployment
Track 4: Emerging Bottlenecks				
Copper	€2.0–4.0B	€800M–1.6B	50–100 kt/yr refined copper from additional sources	Secures long-term supply for electrification; positions EU ahead of tightening global market
Green Ammonia	€1.5–3.0B	€0.8–1.6B	250–500 kt/yr green ammonia replacing grey imports	Establishes clean ammonia supply chain; displaces carbon-intensive imports for fertiliser and shipping fuel
Portfolio Total	**~€19–36B**	**~€9–18B**	**~2× leverage on public funds**	

Note: Capital ranges are rough order-of-magnitude (ROM) estimates derived from comparable transactions, publicly disclosed project costs, and industry benchmarks (IEA, USGS, SFA Oxford, Benchmark Minerals Intelligence, company filings). Public/private splits reflect illustrative instrument mixes. Supply outcomes are directional estimates subject to market conditions and execution timelines.

CTPI analysis provides illustrative transactions to alleviate vulnerabilities across ten key supply chain segments

Each illustrative transaction is built around three building blocks

Investment case

The strategic and commercial rationale: the vulnerability addressed, demand outlook, and the case for intervention.

Proposed capital stack

An indicative public-private blend — equity, DFI debt, and offtake guarantees — with total mobilisation and leverage.

Partnership models

The model matched to each requirement: inward investment, joint ventures, strategic equity, imports, and anchor offtake.

Go deeper

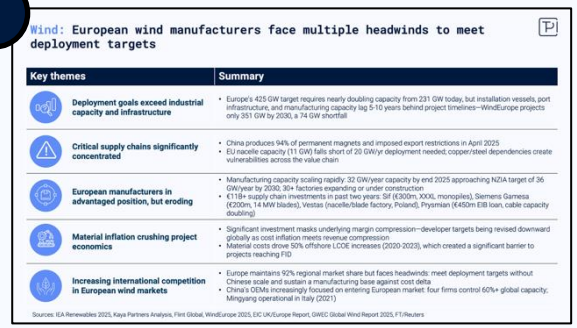
Each transaction is detailed in the deep-dive sections — diagnosis, capital stack, and partner models.

Reach out to the CTPI team for details.

Focus energy technologies contain deep dive analysis on market trends, supply chain vulnerabilities, and industrial competitiveness to scale CTPs

Key insights

1



Market trends

Summary of key market developments for technology, supply chain, and domestic production

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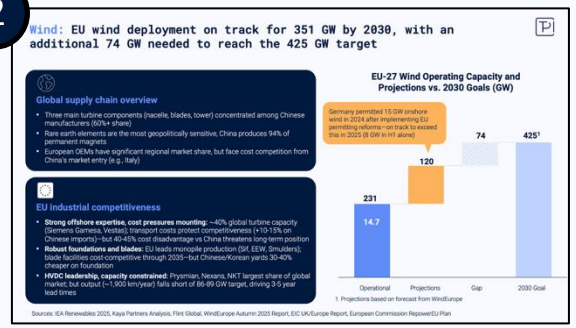

Goals and targets

Overview of domestic goals for energy technology deployment including current capacity and gap

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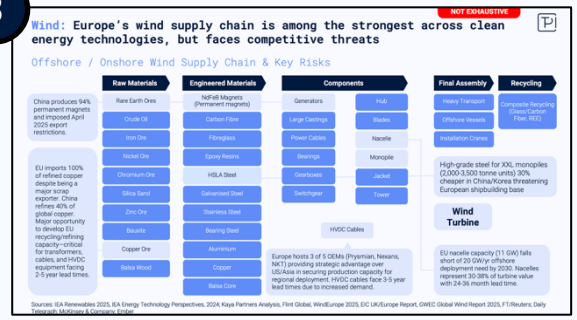

Supply chain map

Detailed view of technology supply chain from raw materials to assembly to recycling

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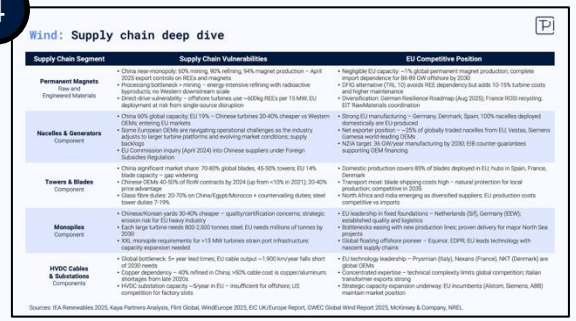

Supply chain matrix

Assessment of vulnerabilities and industrial competitiveness of key supply chain segments for given energy technology

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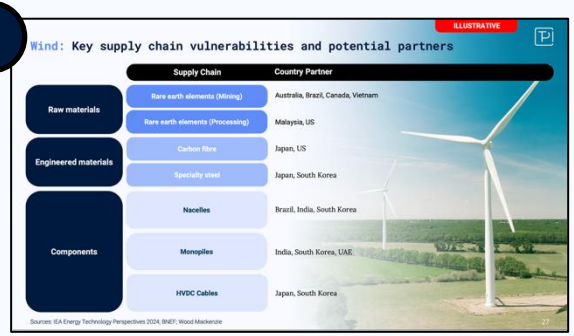


Partnerships

Matching of supply chain vulnerabilities with potential international and commercial partnerships

> Worked example follows:
> **Wind deep dive**

From portfolio to proof: One chain, end to end

The portfolio is built from chain-by-chain analysis. The next section applies the full method end-to-end, with wind as the worked example.

The wind deep dive moves from market headwinds to a complete supply chain map, a segment-level vulnerability matrix, and candidate partner countries and companies.

It closes with one of the ten transactions in full: the rare earth / permanent magnet partnership — strategic rationale, capital stack, and partnership models.

Every chain in the portfolio is assessed the same way — profiles of the remaining technologies follow, with full deep dives available from the CTPI team.

Wind: European wind manufacturers face multiple headwinds to meet deployment targets

Key themes	Summary
Deployment goals exceed industrial capacity and infrastructure	• Europe's 425 GW target requires nearly doubling capacity from 231 GW today, but installation vessels, port infrastructure, and manufacturing capacity lag 5-10 years behind project timelines— projects only 351 GW by 2030, a 74 GW shortfall
Critical supply chains significantly concentrated	• China produces 94% of permanent magnets and imposed export restrictions in April 2025 • EU nacelle capacity (11 GW) falls short of 20 GW/yr deployment needed; copper/steel dependencies create vulnerabilities across the value chain
European manufacturers in advantaged position, but eroding	• Manufacturing capacity scaling rapidly: 32 GW/year capacity by end 2025 approaching NZIA target of 36 GW/year by 2030; 30+ factories expanding or under construction • OEMs have committed €11B+ supply chain investments since 2023 including nacelle and blades factories, monopolies, and subsea cables
Material inflation crushing project economics	• Significant investment masks underlying margin compression—developer targets being revised downward globally as cost inflation meets revenue compression • Material costs drove 50% offshore LCOE increases (2020-2023), which created a significant barrier to projects reaching FID
Increasing international competition in European wind markets	• Europe maintains 92% regional market share but faces headwinds: meet deployment targets without Chinese scale and sustain a manufacturing base against cost delta • Four Chinese firms produce 60%+ of global production for wind supply chain components and increasingly focused on entering the European market with one facility becoming operational in 2021

Sources: IEA Renewables 2025, Kaya Partners Analysis, Flint Global, WindEurope 2025, EIC UK/Europe Report, GWEC Global Wind Report 2025, FT/Reuters

Wind: EU wind deployment on track for 351 GW by 2030, with an additional 74 GW needed to reach the 425 GW target

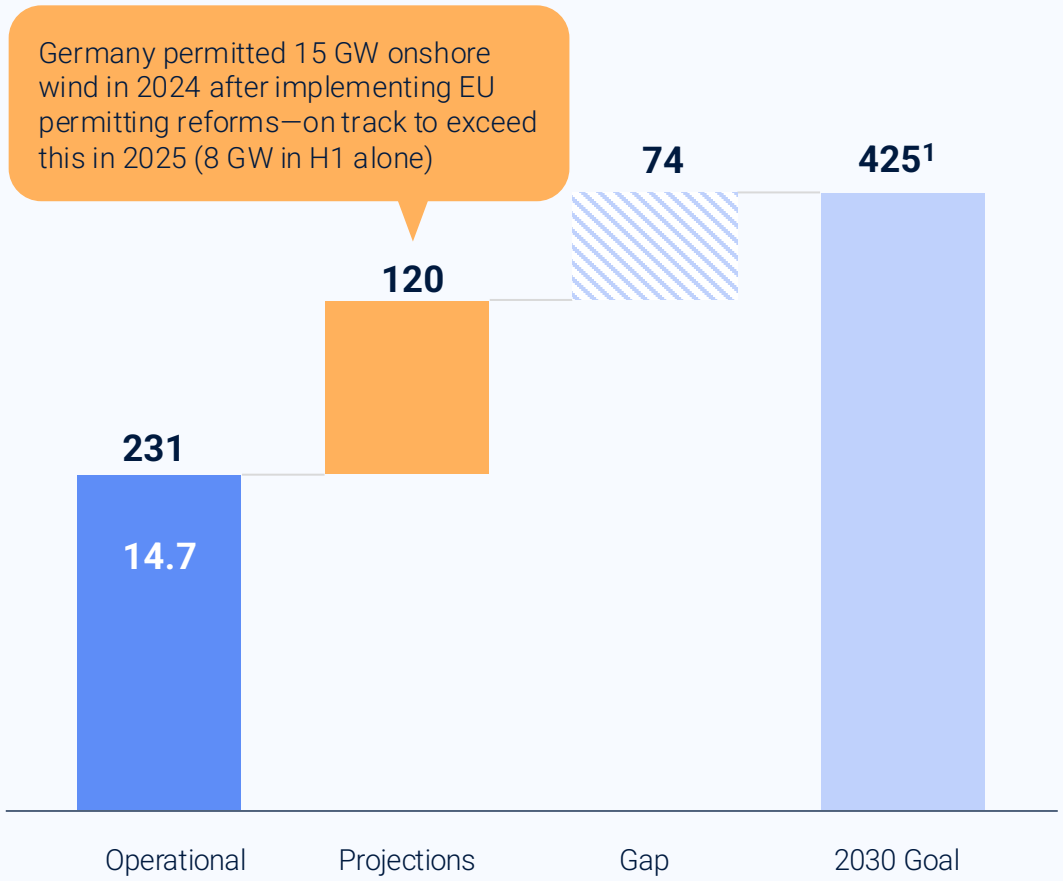
Global supply chain overview

- Three main turbine components (nacelle, blades, tower) concentrated among Chinese manufacturers (60%+ share)
- Rare earth elements are the most geopolitically sensitive, China produces 94% of permanent magnets
- European OEMs have significant regional market share, but face cost competition from China's market entry (e.g., Italy)

EU industrial competitiveness

- **Strong offshore expertise, cost pressures mounting:** ~40% global turbine capacity; transport costs protect competitiveness (+10-15% on Chinese imports) - but 40-45% cost disadvantage vs China threatens long-term position
- **Robust foundations and blades:** EU leads monopile production globally and blade facilities cost-competitive through 2035 - but Chinese yards 30-40% cheaper on foundations
- **Global leadership for the production of HVDC and subsea cables:** but output (~1,900 km/year) falls short of 86-89 GW target, driving 3-5 year lead times

EU-27 Wind Operating Capacity and Projections vs. 2030 Goals (GW)



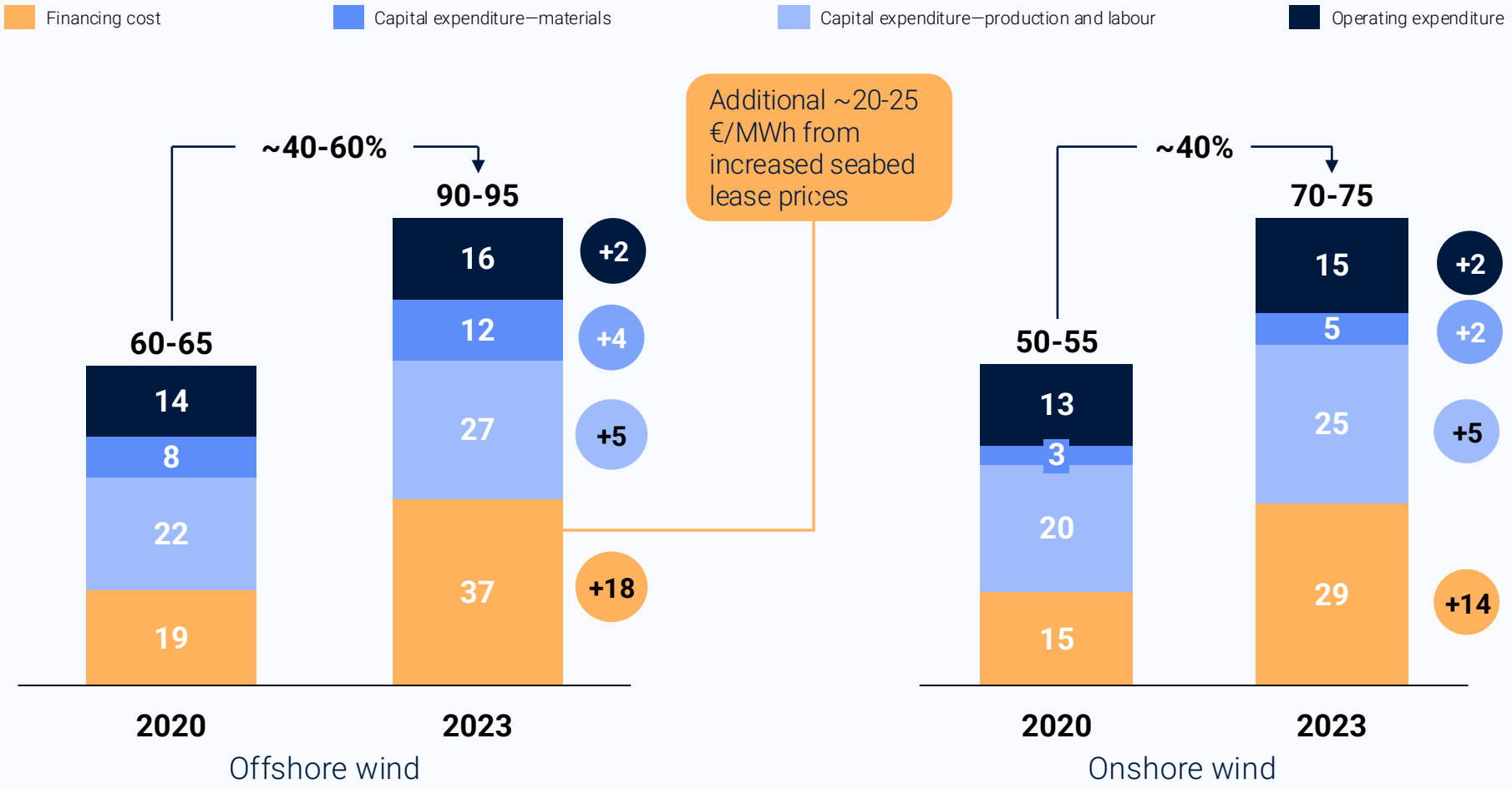
1. Projections based on forecast from WindEurope

Sources: IEA Renewables 2025, Kaya Partners Analysis, Flint Global, WindEurope Autumn 2025 Report, EIC UK/Europe Report, European Commission RepowerEU Plan

Wind: Increased material costs, inflation, interest rates, and competitive seabed tenders have increased LCOE

Levelised Cost of Energy: Offshore and onshore wind, 2020-2023

LCOE Germany, € per MWh by year of FID (nominal)



Key insights

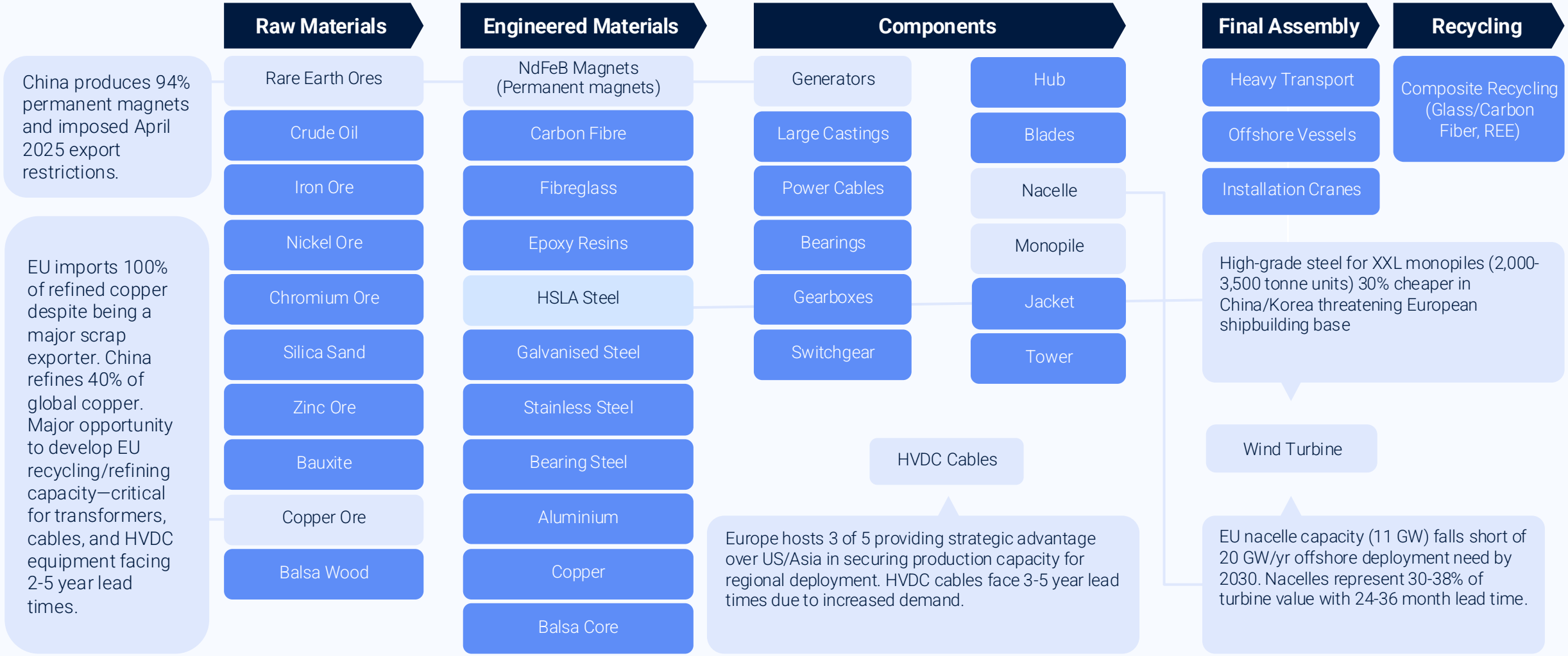
- **Capex increasing:** Offshore wind's greater cost exposure stems primarily from its higher capital intensity—financing costs increased by +18 €/MWh offshore vs +14 €/MWh onshore, and materials capex rose +4 €/MWh vs +2 €/MWh for onshore
- **Supply chain underinvestment:** Low OEM margins have driven insufficient capacity investment to meet government targets
- **Material cost exposure:** Higher capital intensity makes offshore wind disproportionately vulnerable to commodity price shocks

Source: McKinsey & Company, "Offshore wind: Strategies for uncertain times," July 12, 2024.
https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/offshore-wind-strategies-for-uncertain-times

NOT EXHAUSTIVE

Wind: Europe's wind supply chain is among the strongest across clean energy technologies, but faces competitive threats

Offshore / Onshore Wind Supply Chain & Key Risks



Sources: IEA Renewables 2025, IEA Energy Technology Perspectives, 2024; Kaya Partners Analysis, Flint Global, WindEurope 2025, EIC UK/Europe Report, GWEC Global Wind Report 2025, FT/Reuters; Daily Telegraph; McKinsey & Company; Ember

NOT EXHAUSTIVE

Wind: Supply chain deep dive

Supply Chain Segment	Supply Chain Vulnerabilities	EU Competitive Position
Permanent Magnets Raw and Engineered Materials	• China near-monopoly: 60% mining, 90% refining, 94% magnet production – April 2025 export controls on REEs and magnets • Processing bottleneck > mining – energy-intensive refining with radioactive byproducts; no Western downstream scale • Direct-drive vulnerability – offshore turbines use ~600kg REEs per 15 MW; EU deployment at risk from single-source disruption	• Negligible EU capacity: ~1% global permanent magnet production; complete import dependence for 86-89 GW offshore by 2030 • DFIG alternative (TRL 10) avoids REE dependency but adds 10-15% turbine costs and higher maintenance • Diversification: German Resilience Roadmap (Aug 2025); France ROSI recycling; EIT RawMaterials coordination
Nacelles & Generators Component	• China 60% global capacity; EU 19% – Chinese turbines 20-40% cheaper vs Western OEMs; entering EU markets • Some European OEMs are navigating operational challenges as the industry adjusts to larger turbine platforms and evolving market conditions; supply backlogs • EU Commission inquiry (April 2024) into Chinese suppliers under Foreign Subsidies Regulation	• Strong EU manufacturing – Germany, Denmark, Spain; 100% nacelles deployed domestically are EU-produced • Net exporter position – ~25% of globally traded nacelles from EU; world-leading OEMs • NZIA target: 36 GW/year manufacturing by 2030; EIB counter-guarantees supporting OEM financing
Towers & Blades Component	• China significant market share: 70-80% global blades, 45-50% towers; EU 14% blade capacity – gap widening • Chinese OEMs 40-50% of RoW contracts by 2024 (up from <10% in 2021); 20-40% price advantage • Glass fibre duties: 20-70% on China/Egypt/Morocco + countervailing duties; steel tower duties 7-19%	• Domestic production covers 85% of blades deployed in EU; hubs in Spain, France, Denmark • Transport moat: blade shipping costs high – natural protection for local production; competitive in 2035 • North Africa and India emerging as diversified suppliers; EU production costs competitive vs imports
Monopiles Component	• Chinese/Korean yards 30-40% cheaper – quality/certification concerns; strategic erosion risk for EU heavy industry • Each large turbine needs 800-2,500 tonnes steel; EU needs millions of tonnes by 2030 • XXL monopile requirements for >15 MW turbines strain port infrastructure; capacity expansion needed	• EU leadership in fixed foundations – Netherlands, Germany; established quality and logistics • Bottlenecks easing with new production lines; proven delivery for major North Sea projects • Global floating offshore pioneer – EU leads technology with nascent supply chains
HVDC Cables & Substations Components	• Global bottleneck: 5+ year lead times; EU cable output ~1,900 km/year falls short of 2030 needs • Copper dependency – 40% refined in China; >50% cable cost is copper/aluminum; shortages from late 2020s • HVDC substation capacity ~5/year in EU – insufficient for offshore; US competition for factory slots	• EU technology leadership – Italy, France, Denmark are global OEMs • Concentrated expertise – technical complexity limits global competition; Italian transformer exports strong • Strategic capacity expansion underway; EU incumbents maintain market position

Sources: IEA Renewables 2025, Kaya Partners Analysis, Flint Global, WindEurope 2025, EIC UK/Europe Report, GWEC Global Wind Report 2025, McKinsey & Company, NREL

ILLUSTRATIVE

Wind: Key supply chain vulnerabilities and potential partners

	Supply Chain	Country Partner
Raw materials	Rare earth elements (Mining)	
	Rare earth elements (Processing)	
Engineered materials	Carbon fibre	
	Specialty steel	
Components	Nacelles	
	Monopiles	
	HVDC Cables	

Sources: IEA Energy Technology Perspectives 2024; BNEF; Wood Mackenzie

ILLUSTRATIVE

Rare Earth Elements / Permanent Magnets:
Reduce single-source dependency for magnets and raw materials

Strategic Rationale

Objective:
Establish alternative supply of rare earths and domestic permanent magnet production for defence and clean energy sectors.

Supply Vulnerability:
China produces ~90% of REE refining and 90%+ of magnet output. April 2025 export restrictions curbed market access.

Diagnosis:
REE market too thin for project finance. Previous state-backed investments (US, Japan) validate direct government equity model.

Risk Mitigation:
Floor-price contracts absorb commodity volatility. Magnet recycling and REE-free R&D as long-term hedge.

Illustrative Deal

Capital Mobilisation: €1.4–2.8B
Public: €940M–1.9B | Private: €460–925M
Leverage: ~1.5X

Partnership Model:
Strategic Equity Stakes + Anchor Offtake. EU governments take 10–15% equity in REE mining and processing, paired with a price floor and full magnet offtake for 10 years.

Outcomes:
Establishes domestic permanent magnet production and secures board influence through 10–15% stakes, leveraging public capital at 1.6–1.7X.

Country Partners:
Australia, Brazil, Canada, Estonia, France, Japan, UK.

clean
technology
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A geoeconomic strategy for Europe

Building clean technology partnerships

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