clean
technology
partnerships
initiative

A geoeconomic strategy for Europe: building clean technology partnerships

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Summary

For nearly two decades, Europe has lived through a rolling series of shocks.

The 2008 financial crisis tested the single currency and reshaped the continent's fiscal architecture. The Covid pandemic exposed the fragility of global just-in-time supply chains. Russia's full-scale invasion of Ukraine weaponised gas pipelines and ended a generation of cheap energy. Most recently, United States (US) and Israeli strikes on Iran opened a new front in the Middle East, putting the Strait of Hormuz, which carries 20 per cent of global oil and gas alongside key commodities like aluminium, fertiliser and sulphur, at the centre of every trading screen.

Europe has found answers each time – emergency measures followed by fading political will as prices stabilise and attention turns elsewhere. But seemingly exceptional events form a pattern – a structural shift from an era of integration and relative predictability to one of great power competition, weaponised interdependence and recurring supply shocks.

As Europe accelerates its energy transition in response to repeated fossil fuel shocks, a different set of problems comes into sharper focus. Clean technology supply chains – from critical minerals to finished modules – are highly concentrated, often overwhelmingly in China. The US, which could be a key partner in diversifying supply chains, is pulling back from some clean technologies and sees Europe less as an essential partner than a subordinate or irrelevance. Within Europe, high energy costs in many countries, limited natural resource endowments and stretched public finances weigh on choices about which sectors to support.

There is, however, positive news. Europe has better options to respond to its vulnerabilities in the new energy economy than to the energy shocks of recent years. It can produce much more of the energy it needs domestically. And it has expertise and capacity in many of the key clean technologies. But it faces critical gaps and vulnerabilities today and emerging constraints and bottlenecks tomorrow which demand that choices are made with intent rather than by default, that they are comprehensive not piecemeal, strategic rather than reactive and that trade-offs are confronted not avoided.

This in turn demands a framework for navigating Europe's competing objectives of reducing excessive dependencies, cutting emissions, supporting key industries, and keeping costs down for citizens and businesses while not inflating public deficits. Self-sufficiency across energy and industrial systems is neither achievable nor desirable: to remain globally competitive, build domestic industry and create high-value jobs, Europe needs partners willing to share parts of the supply chain. Its goal should be to anchor higher-value activities in Europe while sourcing upstream inputs it cannot provide from trusted partners.

The Clean Technology Partnerships Initiative (CTPI) provides a data-driven, technology-neutral framework for prioritising sectors for public policy intervention and investment across Europe and with key partner countries. It evaluates supply chain vulnerabilities, risks and industrial competitiveness to identify partnerships and build commercially viable supply chains by:

> **Prioritising clean energy technologies** through three lenses; national security, energy resilience and economic growth.

> **Identifying the supply chains within these technologies where partnership can do most to reduce dependency**, focusing on those with the greatest concentration risk, capacity shortfalls, or cost disadvantage according to the nature of the constraint: geopolitical chokepoints, strategic manufacturing, capacity constraints in trusted partners and emerging bottlenecks.

> **Matching each requirement to a small group of trusted partner countries and the right partnership mode**l – from inward investment and joint ventures to strategic imports, equity stakes and offtake agreements, sequenced by urgency, execution speed and value-chain interdependency to deliver globally competitive, resilient supply chains.

Applying this framework, we select eight key technologies – batteries, offshore wind, grid equipment, nuclear, heat pumps, geothermal, green steel and green ammonia – and from these the ten highest priority supply chain interventions. A relatively small number of trusted partners – including South Korea, Japan, Australia, Canada and Brazil – can anchor multiple supply chains. We recommend government-led partnerships for coordinated sourcing, investment, deployment and manufacturing: transactions and policy actions of mutual benefit to governments and industry that secure critical inputs, anchor domestic industrial capacity, and lower deployment costs where self-sufficiency is impractical.

We assess that investment across Europe of €19-36 billion in ten supply chains, roughly half of which is public finance, would result in 10-15 per cent of additional production capacity in partner countries in critical technologies. This compares to current annual investments in Europe's energy system of well over €600 billion and would materially reduce Europe's vulnerabilities in key sectors, strengthen key trade and investment relationships and secure inputs for critical industries.

Recommendations

What to prioritise

Focus intervention on a prioritised set of critical clean energy supply chains — ten supply chains where energy resilience, national security and growth objectives converge, and where vulnerabilities can be materially reduced through external partnerships. Immediate intervention should be focused on the most acute chokepoints: rare earths for permanent magnets, electrode active materials (graphite anodes, lithium-ion cathodes) for batteries and nuclear fuel.

Build these partnerships with a small number of trusted partner countries (such as South Korea, Japan, Australia, Canada and Brazil) that anchor multiple priority supply chains, concentrating effort on the relationships that matter most.

How to deliver

Focus partnerships on specific transactions, matching each supply chain gap to a deal, partner country, instrument mix and capital model, using the lightest effective instrument in each case. Offtake agreements and guarantees, for example, can often secure supply at lower cost than equity investment or building new capacity.

Coordinate between UK, EU and other European governments to aggregate demand and financing where national markets alone are insufficient to anchor investment at the required scale, managing coordination in a light-touch way, independent of any formal UK-EU negotiations.

Deliver through a sequenced investment programme (estimated €19-36 billion), underpinned by €9-18 billion of public capital that crowds in private investment, and brings these supply chains to global competitiveness providing a catalyst to commercial viability, not a perpetual subsidy. Each transaction is independently viable, but together they reinforce one another.

Build a transaction capability to deliver at pace, using existing institutions to originate, structure and close deals by combining export credit, development finance and investment tools into a strategic execution capability.

Align with the diplomatic calendar – partnerships, summits and ministerial timelines – to convert political declarations into binding commercial agreements.

Introduction

The challenge

A more volatile geopolitical environment has exposed tensions in Europe's energy transition. On the one hand, wars in Ukraine and the Gulf have strengthened the case for clean energy. On the other, Europe has little control over the clean energy supply chains on which it will increasingly depend; capacity constraints are weighing on deployment; and high energy costs are making parts of some sectors uncompetitive.

China has spent decades investing in key stages of clean energy manufacturing. It controls 70 to 90 per cent of the battery value chain, 75 to 95 per cent of solar PV manufacturing, 90 per cent of rare earth refining, and 94 per cent of magnet production necessary for wind turbines, electric vehicles (EVs) and defence systems (IEA, 2026). And it has been willing to use this dominance in some sectors for geopolitical objectives. In April 2025, amid escalating trade tensions with the US, China introduced export licensing on seven medium and heavy rare earth elements and related magnets. Key components like magnets became harder to source, delivery times more than doubled and around one in five European wind projects were delayed (S&P Global, 2026).

Cost gaps between European and Chinese tech create a parallel squeeze. Around a quarter of planned European gigafactories have been delayed or put at risk because Chinese producers can make cells 30 to 50 per cent more cheaply, raising EV costs and slowing uptake (Rhodium Group, 2025; BNEF, 2025). Europe is also falling behind on hydrogen, with only a few gigawatts of electrolyser capacity installed (equipment that uses electricity to split water into hydrogen) and Chinese systems up to 40 per cent cheaper (IEA, 2026).

Europe also faces pressures from an increasingly protectionist US, which is seeking to reshape supply chains including through tariffs and export controls. Under the Biden Administration, the Inflation Reduction Act accelerated a global subsidy race by pairing state support with managed market access. The second Trump administration has reshaped supply chains on explicitly national lines while retreating from the international frameworks intended to manage the spillover effects of domestic economic policy. As a result, Europe now operates in a system in which both major powers are shaping markets in ways that negatively affect its industrial base.

For European policymakers, the energy transition now sits at the centre of economic and security policy. That requires choices about supply chains, technologies and partners which are often in tension. Chinese technology will generally remain the cheapest and fastest route to deployment, even as dependence creates risk. Efforts to maintain or rebuild domestic capacity can raise costs, slow deployment and invite retaliation. The US remains an important supplier and partner but can no longer be relied on not to exploit its position.

Europe has set out a range of policies to address these challenges. In the EU, the Net Zero Industry Act (NZIA) and REPowerEU aim to accelerate deployment and support domestic production, while the Clean Industrial Deal targets sectors for global competitiveness. The EU has also developed Clean Trade and Investment Partnerships to build supply chains primarily focused on securing raw materials and imports. The proposed Industrial Accelerator Act aims to strengthen the EU's industrial resilience by streamlining permitting, creating lead markets for low-carbon products and ensuring foreign direct investments in strategic sectors provide domestic value.

The UK has pursued similar objectives through its Modern Industrial Strategy and Clean Power 2030 Action Plan, alongside instruments such as Great British Nuclear and the National Security Investment regime. However, neither the UK nor the EU has set out a framework for deciding what to build domestically, what to source externally and where security considerations justify higher-cost diversification. This risks leading to action by governments which is ineffective and incoherent, or simply to inaction – and so ultimately to Europe's choices being determined by other powers.

Chapter 1

Methodology

Extensive open-source analysis exists on supply chain risks, but much of this assesses exposure without clearly differentiating between vulnerabilities. A more structured framework is needed to identify where Europe's competing objectives converge, and where targeted intervention can material reduce strategic exposure at reasonable cost.

The framework proposed in this report has a five-part methodology:

1. First, it **prioritises across technologies** by applying a national security, energy resilience and economic growth lens to identify technologies where targeted intervention through third-country partnerships could improve unit economics for domestic manufacturers and materially reduce strategic exposure at reasonable cost. This results in selecting eight technologies from a longer list of 16 (Table 1 and Annex B).

2. Second, it **identifies supply chain vulnerabilities within these technologies** – including concentration risk, capacity shortfalls and cost competitiveness gaps – and assesses the feasibility of addressing them through partnership. This results in selecting ten priority supply chains within the eight technologies identified in the first stage[1].

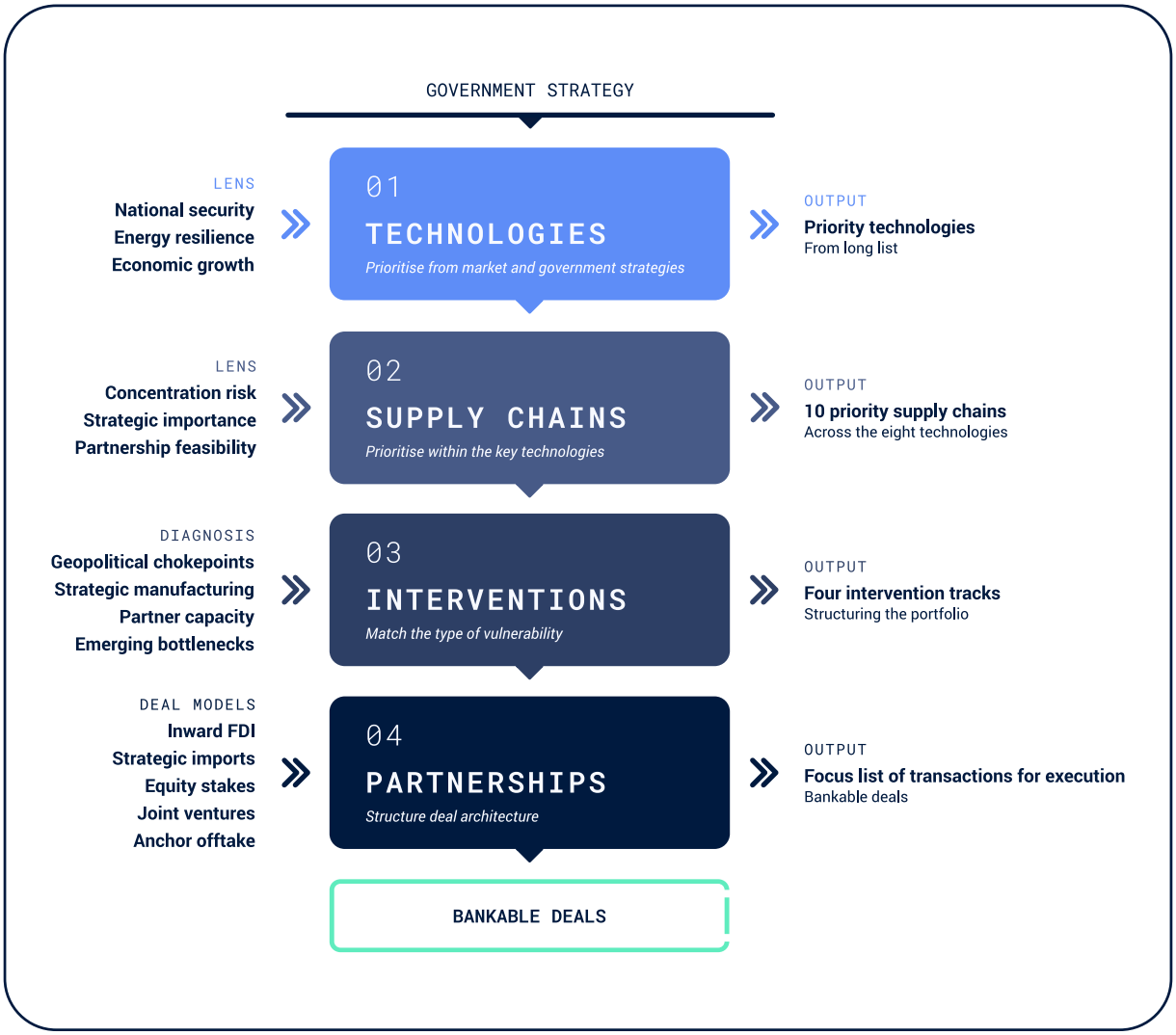
3. Third, it takes an **outcomes-based approach** to interventions, organising actions by the nature of the constraint they address: geopolitical chokepoints, strategic manufacturing, capacity constraints in trusted partners and emerging bottlenecks.

4. Fourth, it **matches each intervention with one or more partnership models**: inward direct investment, strategic imports, strategic equity stakes, joint ventures and anchor offtake agreements.

5. Fifth, it **sequences execution by urgency, execution speed and value chain interdependency**, given limits on public capital and delivery capacity.

[1] The analysis focuses on supply chains specific to clean energy and industrial technologies. Cross-cutting domains such as cyber security, semiconductor supply chains and infrastructure deployment are excluded. These span a wide range of sectors well beyond clean energy, and are better addressed through dedicated government-wide strategies rather than within a technology-specific partnership framework.

Figure 1: Technology selection methodology



The results are ten transactions with proposed partners, a partnership model and investment structure. We assess these to be the highest priority transactions for European governments in the clean energy and technology sectors based on their stated policies. Policymakers, using the same approach, could weigh security, resilience and growth factors or transaction types differently. The aim of the CTPI is to provide a framework for evidence-based decisions and so to address a gap in policymaking – although governments have recognised the case for international partnerships to address vulnerabilities, they have not created a clear framework to translate this into project proposals that can be advanced with private sector partners.

Chapter 2

Focus technologies

We assess sixteen clean energy technologies identified in UK and EU policy frameworks against the three tests in Figure 2 below, which narrows the focus to eight technologies. Technologies that meet only one or two of these criteria are not prioritised (see Annex B for technologies not prioritised). For each of these eight technologies, we assess the extent to which vulnerabilities can be reduced through targeted international partnerships. Of these eight, six carry forward into the transaction portfolio in Chapter 6 (geothermal and heat pumps are prioritised for domestic and deployment-side measures set out in Annex B).

Figure 2: Technology prioritisation framework

National security

Can we accept control of this supply chain by non-trusted partners?

Assesses degree of concentration in critical supply chain segments, as well as potential intent to cause supply chain disruption. 'Control' is defined as single-country concentration above 50%, with dominance above 70% by a non-trusted source constituting an acute vulnerability or "chokepoint". Examples of supply restrictions are factored into the assessment of intent. Technologies are prioritised where such chokepoints exist or where dual-use characteristics (for example in nuclear, steel or grid infrastructure) preclude reliance on non-trusted suppliers.

Energy resilience

Can we operate a reliable, affordable energy system without secure access to this technology?

Assesses whether disruption would delay or prevent delivery of binding deployment targets. REPowerEU and the UK's Clean Power 2030 mission require rapid scaling of wind, solar, heat pumps and grid infrastructure, which are all dependent on manufactured components with concentrated supply and long lead times.

Economic growth

Does investment generate domestic value at scale?

Prioritises technologies where EU and UK firms hold, or can credibly build, competitive positions in large or fast-growing markets, and where investment supports jobs, exports and industrial capacity. This includes both offensive opportunities (for example grid equipment and wind) and defensive sectors where industrial ecosystems are at risk (including batteries and steel).

Batteries

Batteries matter for decarbonisation, industrial competitiveness, strategic manufacturing, defence and wider economic growth. Batteries are central to electrification in the transport and power systems and increasingly relevant to the defence industry. They account for 30 to 40 per cent of EV value, and European demand is projected to reach 3-4 TWh by 2030 (Rhodium Group, 2026).

Europe's vulnerabilities are concentrated in upstream materials and cell manufacturing. China controls 70-90 per cent of the battery value chain, including around 90 per cent of cathodes, 85 per cent of anodes and 75 per cent of cells, with even higher concentration in engineered materials and refining (IEA, 2026). European producers face a 40-50 per cent cost disadvantage (BNEF, 2025), and much of the gigafactory pipeline remains commercially fragile.

Batteries are well suited to third-country partnerships because Europe cannot replicate all of these upstream segments domestically at competitive cost, but it can reduce dependency by building trusted alternatives in selected stages of the supply chain. Partnerships with countries able to supply graphite and anode materials, cathode materials and cells can diversify exposure, while European policy can continue to support domestic assembly, recycling and downstream manufacturing. The objective should be selective diversification, not full value chain replication.

In diversifying battery supply chains, governments face a trade-off on cost, speed and terms of access. Chinese cell manufacturers currently offer cheaper and faster supply than Japanese or South Korean firms, and the only at-scale source of lithium iron phosphate (LFP). The trade-off is on terms of access. Chinese investments in Europe have typically retained cell IP, process know-how, and the upstream supplier base in China; European Original Equipment Manufacturers (OEMs) have not been granted leading technology or favourable joint venture (JV) terms. Japanese and Korean firms have a longer record of partnering with Western OEMs on terms that share cell technology and bring cathode, anode and electrolyte suppliers onshore. A Korean- or Japanese-anchored European base secures that access at a cost premium; a Chinese-anchored base is cheaper in the near-term but leaves technology, upstream value and the upgrade path under foreign control.

Grid equipment

Grid equipment is the enabling infrastructure for the entire energy transition. The scale of required investment is vast, with hundreds of billions of euros needed by 2030. This is an area of industrial strength given European firms remain global leaders in transformers, cables and control systems. These assets are also critical national infrastructure (CNI), meaning that supply disruption directly affects resilience and recovery from shocks, including cyber and physical attacks. Cybersecurity of grid equipment is an increasingly central concern: transformers, inverters and control systems are now networked assets, and European governments increasingly consider trusted-supplier sourcing essential to managing supply disruption and the risk of embedded vulnerabilities in foreign-manufactured components.

Europe's vulnerability lies less in single source dominance than in severe capacity and input constraints. Transformer lead times have extended to 120 to 210 weeks (Wood Mackenzie, 2025), cable production is limited to a small number of suppliers, inverters and power electronics are highly concentrated in Chinese supply and key inputs including copper and grain-oriented electrical steel have seen sharp price rises and concentrated supply.

Grid equipment is well suited to third-country partnerships because, despite Europe's strengths, it cannot expand capacity quickly enough on its own. The core challenge lies in securing inputs and relieving bottlenecks. Partnerships can help secure copper and electrical steel, bring in external manufacturing capacity and shorten delivery timelines in the most constrained parts of the chain, while allowing European firms to focus on higher-value segments.

Offshore wind

Offshore wind is central to European decarbonisation and one of Europe's strongest clean technology industries, with roughly 40 per cent of global turbine capacity (Wind Europe, 2025). It is essential to meeting EU and UK deployment targets (REPowerEU targets around 100 GW offshore), while also supporting a major area of industrial strength.

Europe's main vulnerabilities lie in a small number of critical inputs and bottlenecks. China controls over 90 per cent of rare earth refining and 94 per cent of permanent magnet production, both essential to turbine manufacture (IEA, 2026). High voltage direct current (HVDC) cables face lead times of more than five years because manufacturing capacity is limited, and deployment is also constrained by shortages in specialised vessels and heavy fabrication capacity (Wood Mackenzie, 2025).

Offshore wind is well suited to third-country partnerships because Europe's weakness is in specific upstream components and system bottlenecks that it cannot quickly solve alone. Partnerships can secure alternative magnet supply, expand cable and vessel capacity with trusted partners and support co-production in constrained inputs without displacing Europe's broader industrial advantages. Partnership in this case is a means of protecting and extending an existing area of strength.

Nuclear

Nuclear provides reliable low-carbon power at scale and underpins energy resilience. In the UK and France, it is also closely tied to strategic industrial capability and to the defence industrial base.

Europe's vulnerability is concentrated in the fuel cycle and heavy industrial inputs. Russia accounts for a large share of the world's uranium enrichment, and remains the only country currently producing enriched fuel – i.e. High-Assay Low-Enriched Uranium (HALEU) – at commercial scale. The specialised factories needed to forge large nuclear components exist in only a handful of facilities. These are acute dependencies in segments where substitution is slow and domestic expansion is already under strain.

Nuclear is well suited to third-country partnerships because no single European country can fully solve these constraints alone within the required timeframe. Only a few trusted partner countries have the facilities and expertise needed for enrichment, HALEU fuel and heavy nuclear manufacturing. By working together, they can combine demand, align funding and scale up capabilities faster. Partnership here is not an alternative to domestic capability but the necessary complement to it.

Geothermal

Geothermal energy is central to scaling across Europe's 19,000 district heating networks and industrial heat applications in the near-term, and baseload power generating capacity in the medium-term (Carnegie, 2025). It is constrained by dependence on a narrow set of critical capabilities, most notably deep drilling rigs and operational expertise. These are concentrated in countries with established oil and gas industries, particularly the US, where shale-era advances have expanded global geothermal potential second only to solar.

Drilling capability, the core input required to unlock next-generation geothermal systems at depth, determines the pace and cost of deployment. European deployment has been insufficient to drive the innovation and cost learning needed to access deeper resources. The weakness is therefore concentrated in execution and expertise rather than across the wider supply chain. Europe retains a viable industrial base in turbine manufacturing and surface equipment, but it lacks competitive drilling capacity – building that capability domestically takes time.

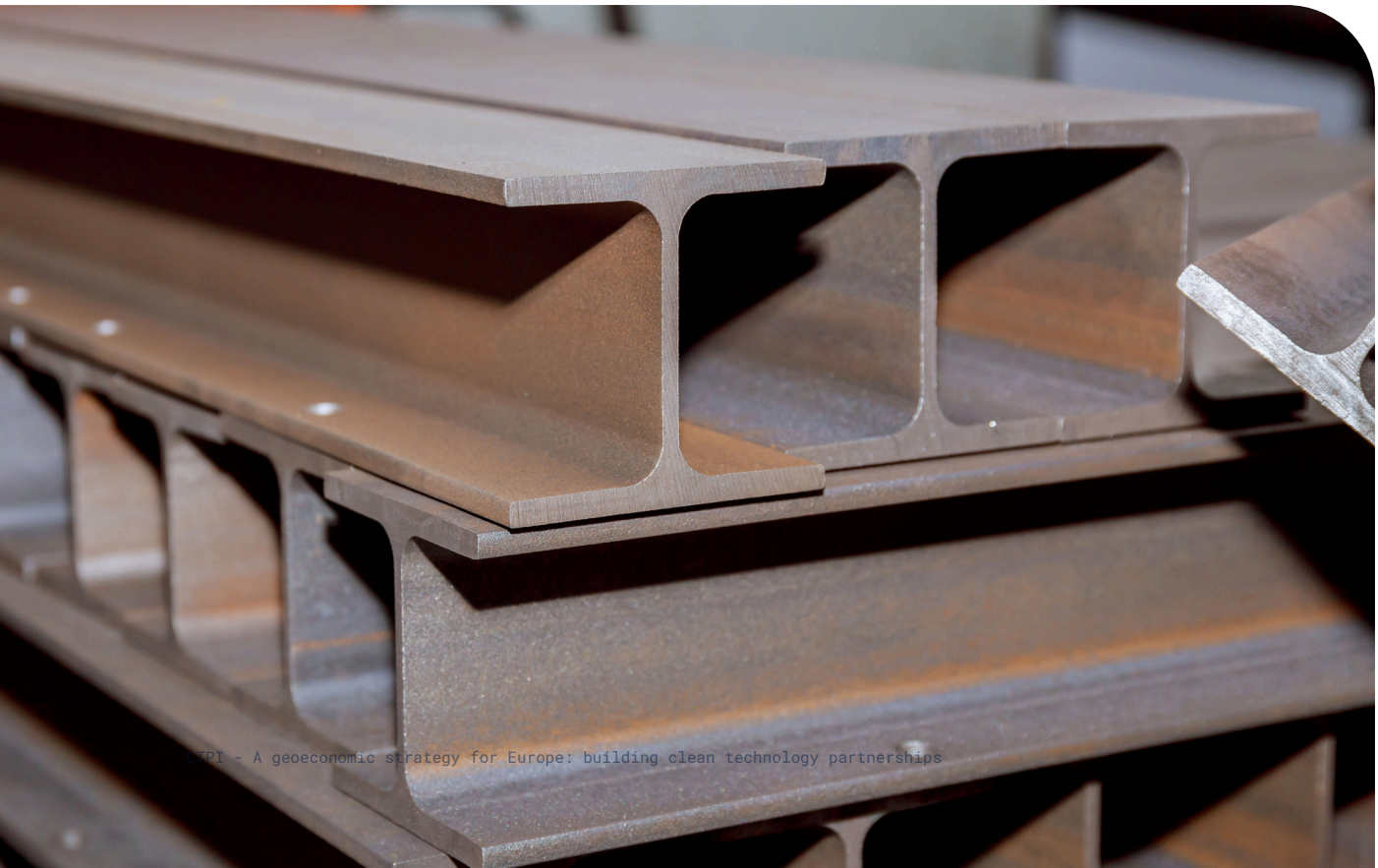
Geothermal is well suited to third-country partnerships, as Europe needs to import expertise in a narrow but essential part of the value chain. Partnerships with established drilling nations – the US, Iceland and countries with specialised rig capability – could accelerate deployment, lower costs through shared learning and transfer operational know-how into European markets, without undermining domestic manufacturers.

Green steel

Steel is a foundational material across construction, defence and clean energy systems and supports a large industrial workforce. It is also by far the largest emitting industrial sector. Green steel is constrained by structural dependence on upstream inputs. Limited availability of the high-quality (Direct Reduction (DR) grade) iron ore needed to make low-carbon steel and high hydrogen costs mean that low-carbon iron production is more competitive in regions with favourable resource endowments.

The main vulnerability lies in access to green iron, particularly processed ("hot briquetted") iron, and to low-cost hydrogen. While some European countries are investing in domestic low-carbon iron production, a number of high-profile projects have been delayed or cancelled, underscoring the fragility of the current pipeline and the likelihood that Europe will remain dependent on imports for a significant share of these inputs. While some steel can be produced domestically by recycling scrap in electric arc furnaces (the steelmaking furnace that uses electricity, rather than coal, to melt metal), scrap supply is limited and is not suitable for all uses, especially where high-quality primary steel is required in aerospace, defence, automotive and nuclear applications.

This is primarily a problem of resource geography and production costs rather than technology. Europe does not have enough of the right raw materials or low-cost energy to produce primary green steel competitively at scale. Long-term agreements with resource-rich countries can secure the supply of green iron and other upstream inputs while allowing Europe to retain steelmaking capacity in downstream stages. In this case, partnership is not a second-best alternative to domestic production. It is the most credible route to sustaining a European steel industry.



Green ammonia

Green ammonia is likely to play a major role in decarbonising fertilisers, shipping and in enabling the long-distance transport of hydrogen. Demand is expected to grow as maritime and industrial decarbonisation policies tighten, making it important both for energy resilience and for low-carbon industrial supply. Conflicts over Ukraine and in the Gulf have underlined Europe's exposure to fertiliser supply disruption. Ammonia production in the UK has ceased due to rising gas prices.

The vulnerability arises from Europe's high costs and from the fact that the market is still at an early stage. Production in Europe remains far more expensive than in regions with lower-cost renewable energy, while uncertain demand and underdeveloped infrastructure have slowed investment. Relying on a small number of foreign suppliers could lock Europe into new long-term dependencies if those supply relationships become too concentrated or dominated by unreliable suppliers.

Green ammonia is well suited to third-country partnerships because this is the kind of early-stage market in which partnerships can shape future trade flows. Europe will not be the lowest-cost producer, but can use long-term offtake agreements, infrastructure co-investment and strategic import arrangements to anchor supply in trusted partner countries before market structures harden. In this case, partnership is not just a response to existing risk but a way to prevent new dependencies from becoming entrenched.

Heat pumps

Heat pumps are the primary technology for decarbonising buildings, which account for around 50 per cent of energy consumption and represent the largest source of gas demand in Europe (Eurostat, 2025). Reducing dependence on imported gas is a European energy security objective. Heat pumps are constrained by dependence on a narrow set of critical components, most notably compressors. China manufactures more than 95 per cent of global supply, alongside dominance in refrigerants and power electronics (IEA, 2026).

Compressors, the core component that circulates refrigerant within a heat pump, account for a large share of the system's cost and are central to the residential market. European manufacturing costs are significantly higher, and recent demand volatility has put domestic investment under pressure. Europe retains a viable manufacturing base in heat pumps overall, but it lacks competitive capacity in the vital component (compressors), and new facilities would take time to build.

Heat pumps are therefore well suited to third-country partnerships, as Europe needs to reduce exposure in a narrow but essential part of the supply chain. Partnerships with established manufacturing countries could expand compressor production, diversify supply and support European assembly, without undermining domestic manufacturers.

Table 1: Prioritised technologies

Technology	Strategic Importance	Key Vulnerability
Power System		
Grid Equipment	Enabling infrastructure for the energy transition. €584bn of EU investment required by 2030 (European Commission, 2025). European firms are global leaders in transformers, cables and control systems.	Severe capacity and input constraints. Power semiconductor scarcity constrains HVDC. EU imports 100% of its refined copper (Eurostat, 2025) – copper scarcity forecast from late 2020s. Components are CNI assets.
Offshore Wind	Core to European decarbonisation and one of its strongest industrials. EU competitive in manufacturing: ~85% of blades, 100% nacelles/towers domestically – net exporter of nacelles. Offshore supply chain gap: 11 GW announced vs 20 GW/yr needed by 2030.	Critical dependence on rare earth permanent magnets, China controls 60% mining, 90% refining (IEA, 2026). Export restrictions in April 2025 exposed supply fragility. Chinese overcapacity has created a 20-40% cost advantage.
Nuclear	Reliable low-carbon power at scale and underpins energy resilience. Linked to strategic industrial and defence capabilities in the UK and France. EU aims to maintain reactor manufacturing and fuel-cycle independence. SMR deployment targeting 15 GW by 2050. Fuel-cycle diversification critical for operational sovereignty.	Dependence on Russia for ~40% of global enrichment (IEA, 2026) and near total reliance on external suppliers for specialised nuclear fuel (HALEU), while the capacity to produce key heavy components is concentrated in a small number of countries, with few alternatives in the West.
Geothermal	Reliable renewable energy that can be used whenever it is needed. Enhanced geothermal systems (EGS) could unlock industrial heating in near-term and baseload power generating capacity in medium-term. Supported by REPowerEU and urban heat planning requirements.	Deployment constrained by drilling costs and capability. Europe lacks recent commercial EGS experience, while expertise is consolidating in US firms. China produces >80% of tungsten used in drilling equipment (IEA, 2025). Dependence on critical inputs such as tungsten and specialised drilling equipment also carries defence industrial risks.

Table 1: Prioritised technologies (cont.)

Technology	Strategic Importance	Key Vulnerability
Enabling Technologies		
Batteries	Central to electrification in transport and power systems and increasingly relevant to defence-industrial capabilities. European demand projected to reach 3-4 TWh by 2030 (Rhodium Group, 2025). NZIA targets 40% domestic manufacturing by 2030, rising to 75% by 2035.	China controls 70-90% of the battery value chain, rising to ~98% in engineered materials (IEA, 2026), with dominance concentrated in upstream processing of graphite, cathodes, anodes and lithium. European production is 40-50% higher cost and commercially fragile (BNEF, 2025). This creates acute exposure in inputs that are difficult to substitute that underpin civilian electrification and dual-use battery applications, increasing vulnerability to supply disruption and coercion. The EU is projected to fall short of manufacturing targets with a sizeable share of projects at high risk.
Heat Pumps	Critical to decarbonising buildings and reducing gas dependence. Europe retains significant manufacturing capacity and targets large-scale deployment (EU: 30 million units by 2030 (European Commission, 2025); UK: 600,000 installations per year by 2028 (UK DESNZ, 2026).	Critical dependence on Chinese compressors (~95% of supply), heat pumps' core component (IEA, 2024). European manufacturing costs are more than double Chinese equivalents, with recent market contraction putting investment at risk.
Industrial Decarbonisation		
Green Ammonia	Key pathway for decarbonising shipping, fertilisers and long-distance hydrogen transport, with demand driven by FuelEU Maritime and IMO targets. European production remains structurally high-cost, making access to imported supply central to meeting decarbonisation, energy resilience and industrial objectives.	Production costs are 3-5× higher than conventional ammonia (Mission Possible Partnership, 2022), with European output uncompetitive relative to regions with lower-cost renewable energy. Supply chains remain underdeveloped, with limited import, storage and bunkering infrastructure. Early reliance on imports risks establishing new long-term external dependencies before diversified supply relationships are secured.
Green Steel	Essential to construction, defence, clean energy systems and supports large industrial workforce. Largest emitting industrial sector. Green H2 steel 20-60% more expensive in Europe. Steel at the centre of the EU's Carbon Border Adjustment Mechanism (CBAM).	Structural dependence on imported high quality (DR-grade) iron ore and high domestic hydrogen costs. Only a minority of planned projects are under construction. This creates downstream vulnerabilities in defence, nuclear and critical infrastructure sectors that require high-grade primary steel and is not substitutable through scrap-based routes.

Chapter 3

Priority supply chains

Across all eight technologies, there is a consistent pattern: vulnerabilities are concentrated in specific segments of the value chain, many of which apply to several technologies; domestic action alone would be insufficient to mitigate the vulnerability; and targeted partnerships can materially reduce exposure.

These supply chain vulnerabilities differ in nature. In some cases, the risk comes from one country controlling key early stages of production. In others, it results from trusted partner countries' lack of capacity, or because the early stage of market formation means that supply chains have yet to be firmly established. These differences determine the form of intervention. Not all supply chain risks require the same response, and in many cases the most effective tools minimise capital intensity while securing access at speed.

The eight technologies show where Europe's core objectives converge; the next step is to identify where targeted intervention would be most effective. Strategic exposure rarely sits evenly across a value chain but concentrates in particular inputs, components or production stages. We therefore select ten supply chains within the eight technologies where supply chain vulnerabilities – including concentration risk, capacity shortfalls and cost competitiveness gaps – coincide with strategic importance, and where partnership offers a feasible route to addressing them (Table 2). These are not exhaustive, but they are the points we assess to be most critical to the convergence of national security, energy resilience and economic growth (geothermal and heat pumps are addressed through domestic and deployment-side measures – see Annex B).

Table 2: Priority supply chains

Technology	Supply Chain Component	Objective	Priority Partner Countries
Batteries	**Cell manufacturing**	Build trusted supplier cell and cathode capacity to reduce Chinese cell share below 50% by 2035 (BNEF, 2025).	South Korea, Japan
Batteries	**Anode active materials (Graphite natural & synthetic)**	Diversify away from China's 89-98% control of anode material processing (IEA, 2026).	Brazil, Canada, Norway, Saudi Arabia
Batteries	**Cathode active materials**	Integrated pCAM/CAM/recycling nodes to build Europe's missing cathode middle.	South Korea
Grid Equipment	**Copper (mining / smelting / refining)**	Secure copper supply for grid equipment and EVs; prices up 50-100% since 2020 (S&P Global, 2025); China controls ~40% of refining (IEA, 2025).	Zambia, Chile
Grid Equipment	**Large power and HVDC transformers**	Reduce transformer lead times that have tripled from 50 to 120-210 weeks since 2021 (Wood Mackenzie, 2025); secure GOES supply (~70% of transformer material costs (DOE, 2021)).	Turkey, South Korea (transformers & GOES)
Offshore Wind	**HVDC subsea cables**	Break capacity bottleneck: only ~5 global producers with 5+ year lead times (Wood Mackenzie, 2025), constraining 130-140 GW offshore pipeline.	Japan, UK
Offshore Wind	**Rare earth permanent magnets**	Diversify from China's 94% monopoly on magnets (IEA, 2026) essential for all offshore turbines (export restrictions imposed April 2025).	Australia, Brazil, Japan, Estonia
Nuclear	**Enrichment & HALEU fuel**	Eliminate dependence on Russian enrichment (40% of global capacity) and sole-source HALEU supply (IEA, 2024).	UK, France (enrichment), US (HALEU)
Green Steel	**Green iron (HBI/DRI) & DR-grade ore**	Secure imported green iron at ~$150/t cost advantage over domestic European production (RMI, 2025); EU will need to import ~50% of green iron by the mid-2040s.	Brazil, Canada, Oman, Australia, Sweden (ore)
Green Ammonia	**Green ammonia production & import infrastructure**	Secure low-cost green ammonia supply for fertiliser, maritime fuel, and hydrogen transport; landed EU cost from producer regions is 40-60% below domestic production (RMI, 2025).	Morocco, Oman, Namibia, Chile, Australia

Chapter 4

Prioritising interventions

Table 2 provides a set of sub-sectoral priorities and potential partner countries. But to inform real world decisions, policymakers also need to know what they should prioritise first. These ten supply chains differ in the nature of the constraint they face, which determines both the urgency of action and the type of instrument required.

The ten supply chains above can be categorised along four lines, defined by the nature of the constraint and the time horizon over which action is needed. At one end are geopolitical chokepoints, where concentrated upstream control (over 70 per cent control by a non-trusted supplier) creates immediate vulnerability and demands rapid action. At the other end are emerging bottlenecks, where markets are still forming and early positioning can shape future supply relationships. Between these sit strategic manufacturing segments, which determine where value is captured but require long-term investment; and capacity constraints in trusted suppliers, where targeted intervention can unlock existing capabilities and accelerate deployment.

Table 3: Categories of intervention

Intervention Category	Definition	Supply Chain Component	Strategic Logic
Geopolitical Chokepoints	Concentrated upstream supply (>70%) by a non-trusted supplier with demonstrated willingness to use that position as leverage, and limited substitution options.	Rare earth permanent magnets; electrode active materials (e.g., graphite - natural & synthetic; lithium- and nickel-based cathodes); enrichment & HALEU fuel.	Risk of geopolitical leverage; no short-term substitutes; speed of access is critical.
Strategic Manufacturing	Segments where Europe must build or secure domestic production capacity to retain industrial value and reduce long-term strategic exposure.	Cell manufacturing & cathode materials; green iron (HBI/DRI) & DR-grade ore; large power transformers & GOES.	Long lead-time assets where investment decisions made now will determine whether Europe retains industrial capacity or locks in permanent dependency through the 2030s.
Trusted Partner Capacity Constraints	Segments where trusted suppliers produce the relevant goods, but at scale insufficient to meet projected demand.	HVDC subsea cables; lithium hydroxide / carbonate.	Capacity shortfalls in trusted markets that are constraining deployment timelines; bottleneck is scale not access, and targeted expansion unlocks system-wide gains.
Emerging Bottlenecks	Early-stage supply chains where demand, infrastructure and trade relationships are not yet fixed, and early intervention can shape future market structure and terms of access.	Copper (refined); green ammonia production.	Markets still forming; early positioning will shape long-term supply relationships into the 2030s.

Within each category, governments then have a choice of instruments – the five partnership models set out in the next chapter.

Chapter 5

Partnership models

Within each intervention category, we define five partnership models that can be used – often in combination – to address the constraints identified in the previous chapter.

Table 4: Partnership models

Partnership Model	When to Use	Trade-offs	Example
Anchor Offtake Agreements: Long-term purchase commitments that provide demand certainty sufficient to anchor new or expanded upstream production and secure supply.	Upstream concentration; early-stage markets; where demand certainty unlocks investment.	Secures supply quickly at low cost, but offers limited control over production and depends on the reliability of the supplier country.	European Hydrogen Bank auctions (€720m first round, 2023) and German Carbon Contracts for Difference (€4bn first round, 2024). Guarantees long-term demand to de-risk investment in materials and components where markets are nascent or lack the scale to support commercial deployment.
Strategic Equity Stakes: Direct public or public-backed ownership stakes in upstream assets to secure access and influence over supply.	Where supply is highly concentrated or exposed to geopolitical risk and long-term leverage is required.	Provides influence and preferential access, but requires significant public capital and carries commercial and political risk if investments fail to deliver returns.	Japan's overseas equity investments in LNG and critical minerals (expanded mandate 2022). Combines public equity with offtake rights to secure preferential access and governance influence over upstream supply in strategically critical sectors.
Inward Direct Investment: Attracts foreign firms to build domestic manufacturing capacity through subsidies, guarantees or market access.	Where domestic capability is limited but can be competitively developed.	Builds domestic industry and jobs, but may require substantial subsidies and without clear conditionality offers limited control over firms or technology.	Samsung SDI battery manufacturing investment in Hungary. Brings critical component manufacturing into Europe by foreign firms in response to demand growth, policy incentives and proximity to end markets.
Joint Ventures: Establishes shared ownership between domestic and foreign firms to develop new industrial capacity, often resulting in technology transfer.	Where domestic capability must be built and retained in strategically important sectors.	Can enable access to leading technology and intellectual property from country partners rather than focus on building mature technology domestically.	Samsung SDI–Stellantis battery joint venture (announced 2021). Combines proprietary technology with guaranteed downstream demand under shared ownership, enabling rapid scaling of domestic manufacturing capacity.
Strategic Imports Secures reliable and diversified access to critical inputs by locking in supply from existing or near-term production in partner countries.	Where domestic production is not available, supply can be secured from existing or scalable producers without the need to anchor new investment.	Fast and capital-efficient, but limited control over production and continued exposure to external shocks.	Japan–Australia Rare Earths arrangement (JARE–Lynas, established 2011; extended through 2038).

Each model corresponds to a distinct supply chain constraint. Upstream concentration and geopolitical risk often require strategic equity stakes or long-term offtake agreements. Capacity bottlenecks in trusted partner markets are typically addressed through inward investment or joint ventures. Where domestic production is not viable, strategic imports provide the most efficient route to securing supply. In practice, multiple models may be needed at different stages of a single value chain.

The partnership models reduce dependency rather than eliminating all engagement with dominant incumbent suppliers, particularly Chinese firms in batteries and clean tech manufacturing. The objective is not to exclude dominant suppliers but to ensure that engagement is structured on European terms, with ownership conditions, technology controls and governance arrangements reducing dependencies that could be exploited. Diversification may also strengthen European countries' negotiating position with Chinese suppliers, for example, when investment, joint ventures or technology transfer is being discussed.

Several of the partnership models depend on the credibility and scale of downstream demand to unlock upstream investment. In a number of priority supply chains, that threshold exceeds what European countries individually can provide. Where this is the case, the viability of the transaction is likely to depend on coordinating demand.

These models are complementary, with a single supply chain often requiring multiple interventions across different stages of the value chain. Resilience in batteries, for example, may require strategic imports of lithium, offtake agreements for processed materials and inward investment in cell manufacturing. Across the five partnership models, offtake agreements and strategic imports are the fastest and most capital-efficient routes; inward investment and joint ventures generate greater domestic value but require longer lead times and more capital; equity stakes offer the strongest long-term control but are the hardest to structure.

Chapter 6

Prioritised transactions and partners

The intervention categories and partnership models can be applied to specific transactions. Table 5 below maps each priority supply chain to partner countries, delivery models and capital structures. Partner countries are selected where they offer the most credible combination of capability, contractable assets and geopolitical alignment.[2]

Table 5: Transactions by intervention category

Geopolitical Chokepoints				
Segment	Lead Partner(s)	Partnership Model(s)	Public Instrument	Total Capital
Rare earth permanent magnets	Australia / Japan	Strategic equity stakes; Anchor offtake agreements.	Strategic equity stake; Export Credit Agency (ECA)-backed offtake guarantee.	€1.5-2.8bn
Graphite (anode material)	Canada / Saudi Arabia	Anchor offtake agreements; Strategic imports & diversification.	Long-term offtake contracts; ECA guarantees.	€0.7-1.0bn
Cathode active materials (integrated facility: pCAM / CAM / recycling)	South Korea	Inward direct investment; Strategic equity stakes.	Government equity stake at 10-15%; IPCEI / Innovation Fund grants; EIB concessional debt.	€2.5-4.5bn
Nuclear enrichment & HALEU	UK / US / France	Strategic equity stakes; Inward direct investment.	Urenco equity leverage; government co-investment in HALEU facilities.	€3.5-7bn
Strategic Manufacturing				
Segment	Lead Partner(s)	Partnership Model(s)	Public Instrument	Total Capital
Battery cell manufacturing	South Korea / Japan	Joint ventures; Inward direct investment.	Co-investment grants; site infrastructure; R&D tax incentives.	€3.5-7bn
Green iron (HBI/ DRI)	Brazil / Oman	Anchor offtake agreements; Strategic imports & diversification.	Anchor offtake via European Hydrogen Bank; port/pipeline co-financing.	€1.5-3.0bn
Large power transformers & GOES	South Korea / Turkey	Inward direct investment; Anchor offtake agreements.	Manufacturing investment incentives; demand aggregation guarantees.	€1.0-2.0bn

Table 5: Transactions by intervention category (cont.)

Trusted Partner Capacity Constraints				
Segment	Lead Partner(s)	Partnership Model(s)	Public Instrument	Total Capital
HVDC subsea cables	Japan / South Korea / UK	Joint ventures; Strategic imports & diversification.	Joint EU-UK demand aggregation; manufacturing co-investment for 525 kV cable technology.	€0.9-1.8bn
Emerging Bottlenecks				
Segment	Lead Partner(s)	Partnership Model(s)	Public Instrument	Total Capital
Copper (mining / smelting / refining)	Zambia	Anchor offtake agreements; Strategic imports & diversification.	Development Finance Institution (DFI) blended capital; ECA guarantees; infrastructure co-investment; political risk insurance.	€2.0-4.0bn
Green ammonia	Morocco / Oman	Anchor offtake agreements; Strategic imports & diversification.	UKEF/EIB-backed 15-20 year offtake; European Hydrogen Bank auctions; port/ bunkering infrastructure co-investment.	€1.5-3.0bn

[2] Capital estimates across the ten illustrative transactions are derived from announced project costs, published company filings and deal structure benchmarks from IEA, S&P Global and comparable financial institution analyses. Each estimate is calibrated as a rough order of magnitude (±15%) against comparable precedent transactions, including Japan's equity stakes and US floor-price contracts with rare earth companies, EU Hydrogen Bank auction results and Important Projects of Common European Interest (IPCEI) battery co-investment rounds. These figures are intended for strategic and policy planning purposes, not investment-grade financial modelling; individual transactions would require detailed due diligence and feasibility assessment before commitments.

The distribution of transactions across the four categories reflects the underlying economics and timing of supply chain risk (see Chapter 4 for the strategic logic of each category). The portfolio is weighted toward chokepoints and strategic manufacturing, where the case for early intervention is strongest and where domestic alternatives are most constrained. Trusted supplier capacity constraints are best addressed through demand guarantees and targeted expansion, unlocking private investment in bottleneck segments. Emerging markets require early positioning to shape supply relationships before they become structurally embedded.

These transactions also concentrate in a relatively small number of partner countries that are strategically significant across multiple supply chains. This concentration could in turn define the diplomatic agenda, with a set of relationships that anchor multiple transactions. Table 6 maps these relationships, identifying the countries that underpin the portfolio and the relevant supply chains. Countries are listed according to their role in anchoring multiple critical supply chains and enabling system-level resilience.

Cooperation on clean energy supply chains also offers a basis for cooperation between European countries and between the UK and the EU. In several of the most capital-intensive segments, individual country demand alone is insufficient to anchor investment at the required scale. Battery materials, rare earth processing and grid equipment all depend on demand volumes and financing structures that exceed national markets. Coordinated demand and aligned financing could therefore improve project economics, strengthen Europe's negotiating position and enable transactions to reach financial close at scale.

UK-EU cooperation on these supply chains does not require comprehensive institutional alignment or the resolution of wider political questions. It can be structured around specific transactions, shared economic interests and time-bound delivery – providing a route for practical cooperation that operates independently of broader UK-EU negotiations.

Table 6: Transactions by partner countries

Countries anchoring multiple priority supply chains			
Partner	Supply Chain Component	Focus	Partnership Model(s)
South Korea	Cell manufacturing & cathode materials; large power transformers & GOES; HVDC subsea cables.	Advanced industrial partner in high-value manufacturing.	Joint ventures; co-investment in manufacturing capacity.
Japan	Rare earth permanent magnets production; HVDC subsea cables.	Advanced industrial partner in high-value manufacturing.	Joint ventures; co-investment in manufacturing capacity.
Australia	Rare earth raw materials; lithium hydroxide / carbonate.	Upstream anchor across critical minerals.	Strategic equity stakes; anchor offtake agreements.
Canada	Lithium hydroxide / carbonate; graphite anode active materials; green iron (HBI/DRI) & DR-grade ore; uranium for enrichment.	Scalable supply potential in key resources.	Strategic equity stakes; long-term offtake agreements.
Brazil	Graphite (natural & synthetic); green iron (HBI/DRI) & DR-grade ore.	Resource and processing hub for industrial inputs.	Strategic imports; anchor offtake agreements.
Countries enabling capacity expansion and industrial scale			
Partner	Supply Chain Component	Focus	Partnership Model(s)
Chile	Lithium hydroxide / carbonate.	Core lithium supplier with established export capacity.	Anchor offtake agreements; strategic imports.
France / US	Enrichment & HALEU fuel.	Partner capability base in nuclear fuel cycle.	Strategic equity; coordinated investment in enrichment.
Turkey	Large power transformers & GOES.	Cost-competitive manufacturing partner in grid equipment.	Inward direct investment; strategic imports.
Countries shaping emerging supply chains			
Partner	Supply Chain Component	Focus	Partnership Model(s)
Morocco / Oman	Green ammonia production & import infrastructure.	Early-stage market anchor for green fuels.	Long-term offtake agreements; infrastructure financing.
Zambia	Copper (integrated production).	Resource partners in emerging critical minerals supply.	Infrastructure co-investment; strategic imports; anchor offtake agreements.
Countries providing additional supply / processing			
Partner	Supply Chain Component	Focus	Partnership Model(s)
India	Graphite (natural & synthetic).	Cost-competitive emerging alternative supplier in battery materials processing.	Strategic imports; anchor offtake agreements.
Norway	Graphite (synthetic).	Trusted processing partner for battery materials.	Strategic imports; anchor offtake agreements.

The transactions and partnerships set out above are not exhaustive – the purpose of this analysis is not to define the full suite of potential partnerships, but to identify those where the strategic case is strongest now and where early action is most likely to deliver system-level impact. A wider set of countries could play meaningful roles in additional technologies and supply chain segments, depending on available capacity, political alignment and the resources governments are willing to deploy, as well as the evolution of technologies.

Chapter 7

Execution

Sequencing

Given the number, scale and interdependence of the transactions identified – and the limits on public capital and delivery capacity – it may not be possible for governments to pursue all simultaneously. The primary intervention categories imply a rough sequencing logic which can be refined with three additional considerations:

Urgency. Priority should be given to supply chains where disruption has already occurred, or long industrial lead times mean delay will lock in missed capacity in the 2030s. Large power transformers, rare earth permanent magnets and graphite (natural and synthetic) are in this category. In each case, the cost of inaction compounds over time.

Execution speed. Where strategic risks are comparable, transactions that can be delivered more quickly should be prioritised. Chokepoint and trusted-partner-capacity transactions, based on offtake agreements and guarantee instruments, can typically reach financial close within six to twelve months. Strategic manufacturing transactions, involving new industrial capacity, take significantly longer. Faster-executing interventions should not be held back by more complex projects.

Value chain interdependencies. Upstream supply and downstream investment are interdependent: securing graphite anode and lithium cathode offtake strengthens the commercial case for battery cell joint ventures, just as grid equipment assembly benefits from reliable access to specialised inputs such as grain-oriented electrical steel. In practice, some investments will proceed in parallel, driven by manufacturing objectives, employment considerations or demand from adjacent sectors. The portfolio is likely to prove most resilient if upstream positions are established early, thereby reducing the risk that downstream commitments are exposed to supply disruption or the threat of being undercut.

Execution models

Execution will differ by partner and the nature of the constraint being addressed. Partnerships with advanced industrial economies operate primarily through corporate relationships anchored by government frameworks where the constraints are coordination and first-mover risk rather than infrastructure or political uncertainty. Public support therefore focuses on guarantees and equity co-investment, allowing transactions to move from agreement to binding commitment within six to twelve months when backed by clear political direction and deadlines. The US-Japan critical minerals framework illustrates this model, combining a fixed financing timeline and project-level commitments tied to political announcements.

In partnerships with emerging economies, the primary constraint is likely to be bankability. Financing must address enabling systems such as power, transport and processing capacity alongside commodity supply, with development finance institutions, blended finance and political risk insurance playing a central role. Timelines are longer, typically eighteen to twenty-four months, and government engagement forms part of the de-risking process, signalling credibility before capital is deployed.

In both cases, when execution fails it tends to do so in predictable ways. The first is mistaking diplomacy for delivery. Agreements and statements can set political direction but do not secure financing. Projects move forward when there are binding, bankable commitments in place. The second is moving too late on demand. Upstream investment depends on clear, credible demand, and when buyers act separately, projects often fail to get financed. The third is slow decision-making in government. When approvals pass through multiple departments, delays build and partners lose confidence.

To address these risks, a dedicated transaction function operating across government is needed with a clear mandate to originate, structure and close deals. This function does not require a new institution; existing export credit agencies, development finance institutions and strategic investment vehicles can be coordinated under a single execution mandate. This function should combine three roles: aggregating demand to create bankable offtake, structuring transactions by matching supply chain gaps to partners and instruments and coordinating finance across export credit, development finance and public investment tools. To be effective, it must have delegated authority and the ability to operate at commercial speed.

Conclusion

European governments have been clear about their objectives: reducing dependence on fossil fuels and the geopolitical disruption it brings, supporting key industrial sectors and addressing climate change. As the energy transition advances, it creates new vulnerabilities that can and should be addressed. The priority supply chains identified in this report account for a disproportionate share of the risk Europe currently carries and require urgent attention.

Existing policies will not be sufficient to reduce these vulnerabilities quickly. Without clearer focus and coordinated execution, supply chain concentration will deepen, industrial capacity will continue to scale elsewhere and exposure to disruption and coercion will increase. These effects compound over time. Capacity built – or not built – in the 2020s will determine security of supply in subsequent decades, and supply relationships now being reshaped will define market access for years to come.

The recommendations in this report are sequenced for impact. Early intervention should target the most acute chokepoints – rare earths, electrode active materials and nuclear fuel – where supply concentration is highest and where the cost of delay compounds fastest. Later-phase investment in strategic manufacturing (grid equipment, subsea cables) and emerging supply chains (green ammonia) can follow as institutional and financing capacity builds. Across the portfolio, public capital of roughly €9-18 billion can structure a total investment of €19-36 billion, materially reducing Europe's exposure across the supply chains that matter most.

This report has focused on the tools required to move from problem description to delivery. It identifies where to intervene, how to structure partnerships, how to aggregate demand to anchor investment and how to build the transaction capability required to reach financial close. It aims to give governments a practical blueprint for action – one that helps navigate overlapping and sometimes competing objectives, while materially strengthening Europe's strategic position.

Annex A

Portfolio supply impact summary[3]

Estimated capacity additions and dependency shifts across ten structured transactions, sequenced by strategic priority.

Segment	Total Capital	Public Capital	Capacity Invested	Supply Outcome
Category 1: Geopolitical Chokepoints				
Rare Earths	€1.4-2.8bn	€0.9-1.9bn	5-10 kt NdPr oxide; domestic NdFeB magnet production	Establishes trusted partner processing and European magnet manufacturing; reduces single-source vulnerability.
Graphite Anode Active Materials	€735mn-1.0bn	€450-615mn	60-100 kt concentrate (30-65 kt AAM after spheronisation yield)	Creates first European anode coating capacity; diversifies supply from near-total Chinese processing.
Cathode Active Materials	€2.5-4.5bn	€800mn-1.5bn	100-130 kt/yr CAM across 5 European nodes (55-75 GWh equivalent)	Builds integrated European cathode manufacturing; covers 10-15% of projected domestic demand.
Nuclear Enrichment	€3.5-7.0bn	€1.5-3.0bn	5-10mn SWU/yr additional enrichment capacity	Secures trusted fuel supply; eliminates remaining Russian dependency in the European energy system.
Category 2: Strategic Manufacturing				
Battery Cells	€3.5-7.0bn	€2.0-4.0bn	100-200 GWh/yr gigafactory capacity	Scales European cell production; reduces reliance on Chinese imports for EV and storage.
Green Iron	€1.5-3.0bn	€0.9-1.8bn	2-4M tpa green HBI for EU steelmaker decarbonisation	Enables cost-competitive green steel; secures low-carbon feedstock from trusted partners.
Grid Equipment	€1.0-2.0bn	€0.5-1.0bn	50-70 GW transformer & switchgear capacity	Expands supplier base and production capacity; eases bottleneck on grid and renewables deployment.

Annex A

Portfolio supply impact summary (cont.)

Segment	Total Capital	Public Capital	Capacity Invested	Supply Outcome
Category 3: Trusted Partner Capacity Constraints				
Subsea Cables	€0.9-1.8bn	€0.45-0.9bn	500-1,000 MVA km/yr HVDC cable production	Increases domestic production capacity; de-bottlenecks 120 GW+ offshore wind deployment.
Category 4: Emerging Bottlenecks				
Copper	€2.0-4.0bn	€800mn-1.6bn	50-100 kt/yr refined copper from restarted smelting and refining capacity in emerging markets	Secures long-term supply for electrification; positions Europe ahead of tightening global market.
Green Ammonia	€1.5-3.0bn	€0.8-1.6bn	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	€~19-36bn	€~9-18bn	~2.0× leverage on public funds	

[3] 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 and do not constitute fiscal commitments. Supply outcomes are directional estimates subject to market conditions, partner commitments, execution timelines, and policy environment. Figures should be read as indicative of scale and strategic impact not forecasts.

Annex B

Priority technologies outside the proposed transaction pipeline

Priority Technologies (without proposed CTP)			
Technology	Strategic Relevance	Why Deprioritised	Recommended Response
Heat pumps	Primary technology for decarbonising buildings. The EU retains ~70% domestic share through 2035 via Vaillant, Bosch, Daikin (EHPA, 2024). UK potential concentrated in industrial heat pumps.	China's 95% share is in volume residential AC compressors – commoditised units scaled for the global cooling market. Europe's need is different: inverter-driven, cold-climate compressors for air-water hydronic systems replacing gas boilers. That segment is Japan/ Korea-led (Daikin, Mitsubishi, LG). Binding constraints are deployment-side: electricity prices, subsidies, building stock policy. EU retains ~70% domestic share through 2035 (EHPA, 2024); UK scope narrower, focused on industrial heat pumps.	EU: deployment-side measures (electricity price reform, F-gas, Clean Industrial Deal €1bn industrial heat pilot); selective component investment. UK: industrial heat pump partnership with Japan (Daikin, Mitsubishi) on high-temperature systems; demand-side support for residential.
Geothermal	Reliable renewable industrial heat and baseload. EU ~40 TW technical potential. Italy holds ~75% of installed ORC turbine capacity (Turboden, Exergy).	Supply chain risks (US drilling consolidation, tungsten) are secondary to the binding regulatory and permitting constraint. Not a focus of UK or EU industrial strategy – absent from the UK frontier industries list; limited dedicated EU funding vs US.	Domestic: permitting reform, EGS standards, North Sea workforce retraining. Joint R&D with the US (Fervo) and Iceland (Landsvirkjun); Anchor the EU pipeline to sustain Italian ORC leadership.

Annex C

Technologies outside the CTP selection criteria

Deprioritised technologies from government strategy documents:assessment rationale and recommended response			
Technology	Strategic Relevance	Why Deprioritised	Recommended Response
Biogas / biomethane	REPowerEU 35 bcm target by 2030; on track for ~68% (IEA, 2025).	Locally sourced feedstock; EU upgrading equipment available. Constraint is feedstock collection and grid injection, not supply chain.	Permitting reform and feedstock infrastructure. Technology and standards exchange with the US and UK.
Carbon Capture, Usage and Storage (CCUS)	Essential for some sectors which are hard to electrify. NZIA targets 50 Mt/yr CO2 injection by 2030.	No dominant global supplier; capture equipment overlaps with O&G and chemical engineering where the EU and UK retain capability.	Co-invest on storage with Norway (Northern Lights) and the UK (HyNet, Northern Endurance Partnership). Technology-sharing with the US.
Hydrogen / electrolysers	EU 10 Mt domestic target by 2030; 340 MW installed vs 6 GW interim (BNEF, 2025).	The EU holds ~25% of global manufacturing. Constraints are electricity costs and offtake, not equipment.	Import at scale. Technology licensing and standards-setting. Joint deployment with Australia and Chile.
Hydropower / pumped storage	Baseload generation and grid balancing.	Mature; established European suppliers (Voith, Andritz). Constraints are geography and permitting.	Modernise the fleet. Accelerate permitting. Partner with Norway (interconnection) and Western Balkans (new-build).
Industrial decarbonisation	46% of EU industrial emissions (Eurostat, 2025). Key focus of EU and UK industrial strategies.	Cross-cutting – risks captured in the underlying technologies. Constraints are energy costs, carbon pricing and demand-side policy.	CCUS cluster collaboration (Teesside, Humber). Japan partnership on high-temperature industrial heat pumps. Align carbon pricing.
Solar PV	REPowerEU 592 GW by 2030. EU <1% of global cell/wafer manufacturing; largest module importer (3x inventory). China 75-95% across the value chain (BNEF, 2024).	Fails industrial competitiveness. EU manufacturing costs significantly above China; market structurally oversupplied. Intervention should target deployment, not manufacturing.	Diversify sourcing (India, Southeast Asia). Next-gen R&D with the US (perovskites, kerfless wafers). Build end-of-life recycling.
Sustainable alternative fuels	ReFuelEU Aviation and FuelEU Maritime mandates. Cost premium 3-5x conventional fuels (ICCT, 2025).	Nascent; no dominant supplier. The EU leads mandates and R&D. Constraints are hydrogen cost and biomass availability.	Strengthen blending mandates. Partner with Chile and Namibia on green hydrogen and e-fuels. US/UK collaboration on certification.

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