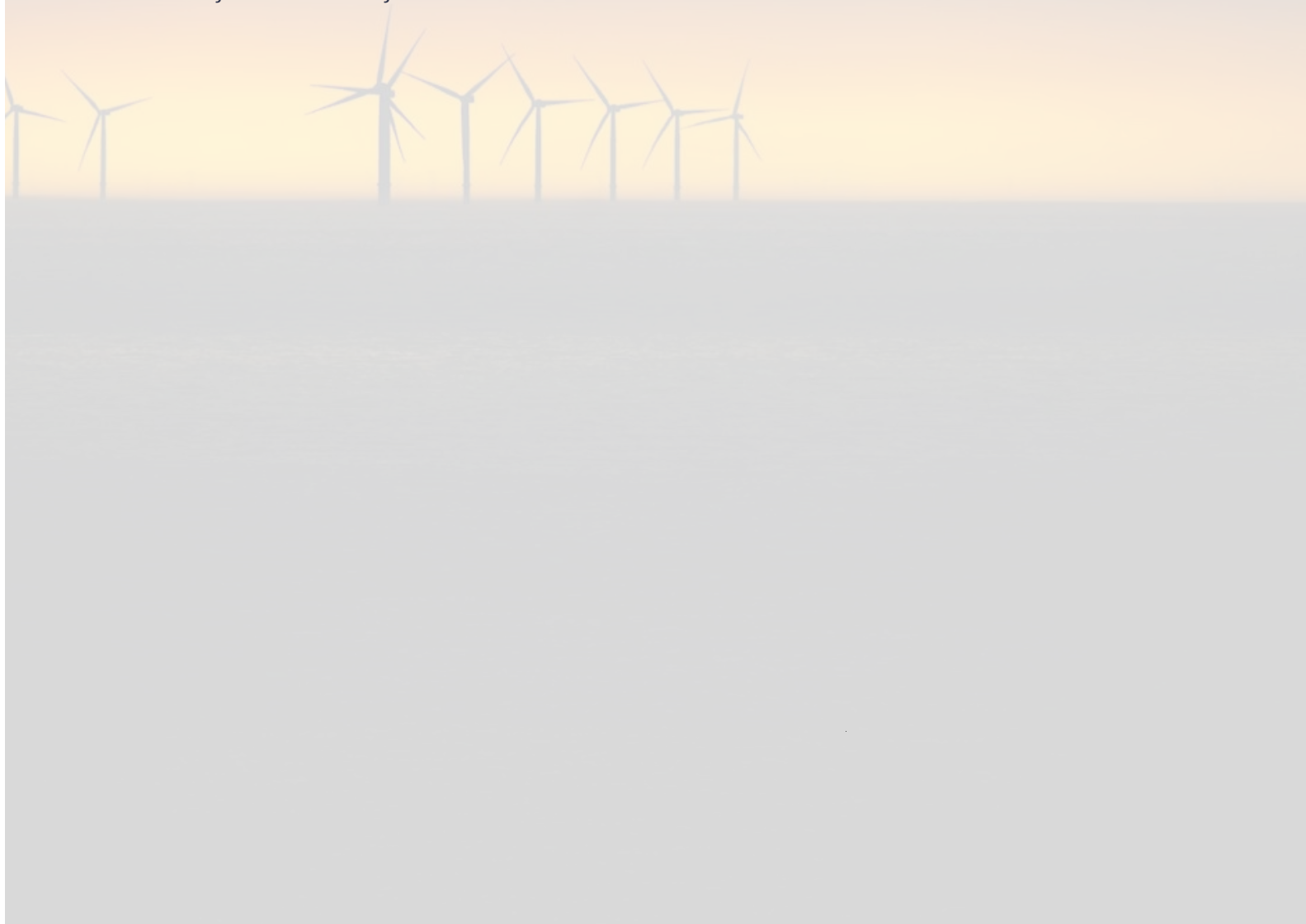


The European Energy Mix and the Impact of Wind Energy through 2040

SUMAS Sustainability Management School

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Submitted to: Jan Erik Meidell · June 2026



Executive Summary

Europe's offshore wind sector is entering a critical phase of expansion, driven by accelerating electrification, energy security priorities, and legally binding decarbonisation targets. Wind energy is projected to grow from approximately **3% of EU electricity generation today to 18% by 2040**, with total renewable generation rising from 48% to 83% of supply over the same period (European Commission, 2024; WindEurope, 2024). The question for the period ahead is not whether wind will dominate European power by 2040, but how fast, at what cost, and which companies will capture the value.

Key Findings

- 1 Policy-Led Growth, Execution-Constrained**
The most likely trajectory for European offshore wind is policy-led growth constrained by execution capacity: permitting reform will unlock project approvals faster than turbines, vessels, port infrastructure, and skilled labour can deliver them.
- 2 Four Scenarios, One Base Case**
Four scenarios were developed across two critical axes — policy and permitting reform, and supply chain resilience — with the Policy-Led Push scenario assessed as the most probable base case (30–35% probability).
- 3 Execution Over Access**
Competitive advantage will shift from access to projects toward the ability to execute them, rewarding institutional depth, supply chain control, and operational reliability over financial scale alone.
- 4 Ørsted's Structural Moat**
Ørsted's thirty years of European regulatory relationships and offshore execution experience represent a structural moat that new entrants, including Chinese state-owned developers now holding over half of global offshore wind capacity, cannot replicate on any compressed timeline (WindEurope, 2025).
- 5 TotalEnergies' Integrated Edge**
TotalEnergies' integrated model of combining offshore wind with storage, power trading, and long-term corporate PPAs positions it to offer industrial customers firm, dispatchable, decarbonised power that pure-play developers cannot match.

Against this backdrop, **Ørsted** must prioritize execution excellence: standardizing project delivery, maximising pipeline throughput, and locking in supply chain access ahead of the next demand surge. **TotalEnergies** must leverage the scale of its 7.5 GW German North Sea hub and its integrated energy capabilities to differentiate on value rather than compete on volume.

Ultimately, the offshore wind market through 2040 will reward companies that resolve the supply chain, not merely those that respond to policy signals. Both companies have what it takes. The question is whether they will deploy it.

Where Wind Energy Stands Today

The European Union (EU) energy mix is transitioning rapidly toward renewables, driven by climate targets, energy security concerns, and technological investment, though fossil fuels still account for a significant share of current consumption. Wind, solar, and hydropower have expanded steadily across member states, while coal use has declined and natural gas continues to play a major transitional role in electricity generation and heating. The EU's policies, including the European Green Deal and the "Fit for 55" package, aim to reduce greenhouse gas emissions, improve energy efficiency, and achieve climate neutrality by 2050. However, differences in national energy strategies, infrastructure limitations, and continued dependence on imported oil and gas present ongoing challenges to a fully renewable energy system.

Current EU Energy Mix

According to Eurostat Energy 2025, the EU's gross available energy in 2023 consisted of approximately:

Energy Source	Share of EU Energy Mix
Oil & petroleum products	~37.7%
Natural gas	~20.4%
Renewables	~19.5%
Nuclear	~11.8%
Solid fuels (coal etc.)	~10.6%

Renewables continue to grow strongly, specifically in electrical generation, where renewables supplied around **46–49% of EU electricity during 2025** (European Commission, 2025a), wind and solar together generated more electricity than fossil fuels for the first time in 2025 (Reuters, 2025), and more specifically wind power alone contributed roughly **17–20% of Europe's electricity generation** (Copernicus Climate Change Service, 2025).

Key Takeaways

- Coal usage is steadily declining.
- Solar energy is growing fastest.
- Wind energy remains one of Europe's largest renewable electricity sources.
- Natural gas is still important for grid stability and backup generation.

Offshore Wind as a Strategic Asset

Offshore wind energy has emerged as a critical component of Europe's decarbonization strategy, playing an increasingly central role in the continent's shift toward renewable electricity generation. Wind energy currently accounts for approximately **17–20% of total EU electricity generation**, with offshore wind representing a growing and significant share of this figure. Europe, and the North Sea region in particular, has established itself as a global leader in offshore wind deployment, with major development activity also concentrated along the Baltic Sea and the Atlantic coast. The United Kingdom, Germany, Denmark, and the Netherlands stand at the forefront of this expansion, collectively driving much of the continent's offshore wind capacity.

The strategic appeal of offshore wind lies in several distinct technical advantages over its onshore counterpart. Offshore installations benefit from stronger and more consistent wind speeds, enabling the deployment of larger turbines and yielding substantially higher electricity output. All commercial-scale offshore wind installations rely on horizontal-axis turbines, with current deployments centered on **14–15 MW platforms**. These characteristics make offshore wind an especially attractive option for meeting large-scale energy demands within the constraints of limited land availability.

Nevertheless, the sector is not without its challenges. Offshore wind development entails considerably higher installation and maintenance costs compared to onshore facilities, compounded by the complexities of grid connection and the demanding conditions of harsh marine environments. These factors continue to pose engineering, logistical, and economic hurdles that the industry must address as it scales.

Looking ahead, the outlook for offshore wind in Europe is markedly ambitious. If current expansion targets are achieved, wind energy has the potential to supply approximately **34% of Europe's electricity by 2030** (WindEurope, 2024). Offshore wind is increasingly projected to become one of the backbone technologies of the European energy system, underpinning the continent's broader climate commitments and its transition to a low-carbon economy.

Wind Energy Currently Installed in Europe

By 2026, Europe's offshore wind sector has reached a significant milestone, with total installed capacity connected to the grid standing at approximately **39–41 GW**. This growth reflects decades of sustained investment and policy commitment across the continent, though the sector's expansion has not been uniform, with a small number of nations accounting for the majority of operational capacity.

15GW

United Kingdom

Unambiguous regional leader — world's most mature offshore wind market (WindEurope, 2025).

9.5GW

Germany

Close second, bolstered by large-scale cluster projects across the North Sea.

5.5GW

Netherlands

Fastest-growing market, reflecting aggressive permitting and tendering activity.

2GW

New in 2025

Subdued year due to post-pandemic supply chain delays; 2026 sees record reversal.

Next Generation of Power

The offshore wind energy sector is currently experiencing a pivotal transition, marked by the commissioning of increasingly large-scale projects and the maturation of advanced turbine technologies. Among the most significant developments is the completion of the first phase of **Dogger Bank A** off the United Kingdom coast, which now stands as the world's largest operational offshore wind farm. The project employs GE's **13 MW Haliade-X turbines**, setting a new benchmark for installed capacity per unit (WindEurope, 2025). Similarly, the EnBW He Dreiht project in Germany reached nearly 50% turbine installation by early 2026, deploying Vestas V236-15.0 MW turbines, some of the largest in commercial deployment to date (WindEurope, 2025). In the Baltic Sea, Poland's Baltic Power project represents the country's first major foray into heavy offshore construction, signalling a broader regional shift toward harnessing the wind resources of the Baltic.

Floating Wind: From Pilot to Commercial Scale

Alongside fixed-bottom developments, floating offshore wind is undergoing a significant transformation from experimental technology to industrial-scale deployment. Europe continues to lead this transition globally, with Norway's **Hywind Tampen (88 MW)** and France's **Provence Grand Large (25 MW)** serving as prominent operational examples (WindEurope, 2025). More recently, concession awards in the UK's Celtic Sea and Norway's Utsira Nord zone have effectively elevated floating wind from pilot-project status to that of a commercially viable, utility-scale energy source.

From a technical standpoint, the industry has coalesced around a new standard: installations commissioned in 2026 predominantly utilise turbines in the **14–15 MW range** (WindEurope, 2025). This represents an almost twofold increase in output per foundation compared to projects built only five years prior, underscoring the rapid pace of technological advancement and the growing cost-competitiveness of offshore wind as a core component of the energy transition.

Electricity Demand and Sources in 2040

Europe's electricity system is approaching a structural transformation. Demand is projected to rise from approximately **2,730 TWh in 2024 to 4,530 TWh by 2040**, a 66% increase driven by economic growth and the deliberate electrification of sectors that have historically run on fossil fuels (IEA, 2024; European Commission, 2024).

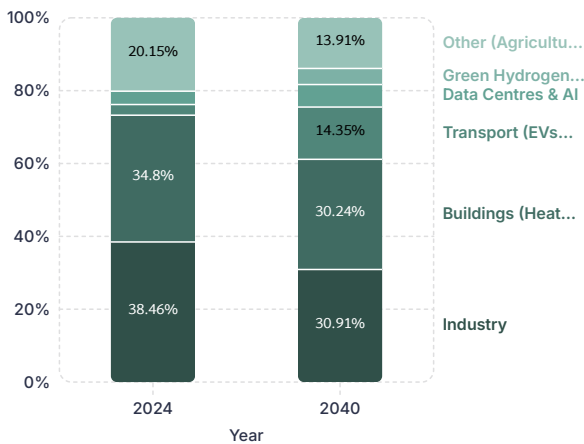
Transport electrification is expected to be a major demand driver (as seen in Table 2), with EV fleet growth projected to add an estimated **570 TWh by 2040**. While the EU's original 2035 internal combustion engine deadline has faced political revision, the structural shift toward electrified transport remains a core assumption in the IEA's demand projections (IEA, 2024).

Projected Energy Demand by Sector in Europe

Sector	2024 (TWh)	2040 (TWh)	Key Driver
Industry	1,050	1,400	Green steel, industrial electrification
Buildings	950	1,370	Heat pump rollout, cooling demand
Transport	80	650	EV fleet growth: ~5M to ~90M cars
Data Centres & AI	100	280	AI/cloud infrastructure growth
Green Hydrogen	10	200	EU 40 GW electrolyser target by 2030
Other	540	630	GDP-linked, offset by efficiency gains
Total	2,730	4,530	—

On the supply side, meeting this demand requires a wholesale restructuring of the generation mix. Renewables are projected to rise from **48% of EU electricity in 2024 to 83% by 2040**, with offshore wind, onshore wind, and solar PV accounting for the bulk of new capacity (European Commission, 2024; WindEurope, 2024). Offshore wind sees the most dramatic growth in proportional terms, from **3% of EU generation today to 18% by 2040**, representing a tenfold increase in output. This trajectory underpins the strategic importance of the sector analysed throughout this report. Figure 1 shows the breakdown of projected electricity demand vs supply by section in 2024 vs. 2040.

Demand by Sector (TWh)



Supply by Source (TWh)

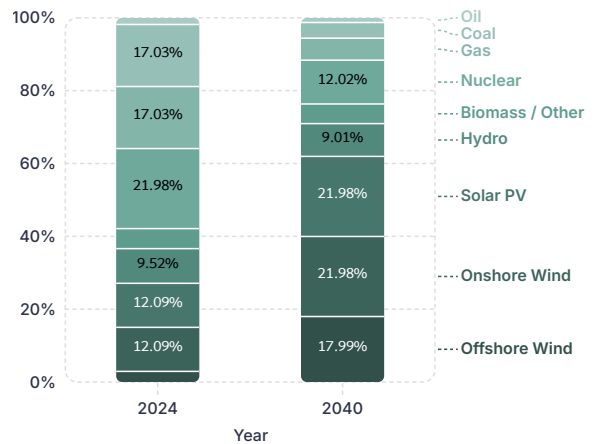


Figure 1a: Demand by Sector, 2024 vs. 2040. Figure 1b: Supply by Source, 2024 vs. 2040. Sources: European Commission 2040 Impact Assessment · Eurelectric · WindEurope · IEA WEO 2024.

Three Structural Forces

Three structural forces make this transition increasingly self-sustaining. First, **binding policy mandates**: the Renewable Energy Directive's 42.5% renewables target by 2030 and the EU's legally enforceable 90% emissions reduction target by 2040 (European Commission, 2025). These create a regulatory floor beneath investment. Second, the **economics have shifted decisively**: solar PV costs have fallen more than 90% since 2010 and wind costs by 60–70%, making renewables the cheapest source of new generation across Europe without subsidy (IRENA, 2025; Ember, 2025). Third, **energy security concerns** following the 2022 Russia-Ukraine conflict have elevated domestic renewable generation from a climate objective to a strategic imperative, accelerating political consensus across member states that had previously been hesitant (Eurostat, 2025).

The implication for offshore wind specifically is clear: the sector is not growing because of policy support alone. It is growing because it is **economically competitive, strategically necessary, and structurally irreplaceable** in a grid that will need to double its output while eliminating fossil fuels entirely.

Bottlenecks of Offshore Wind

Europe's offshore wind sector faces a convergence of regulatory, financial, and logistical constraints that collectively threaten its growth targets. While the technology itself is mature and commercially proven, the infrastructure and institutional frameworks required to deploy it at scale are lagging significantly behind ambition. Three structural bottlenecks stand out as the most consequential: permitting and policy execution, grid capacity, and supply chain readiness.

Policy Hurdle: Permitting Timelines

Permitting remains the most immediate administrative barrier to offshore wind deployment across Europe. Average approval timelines range from **three to five years** in the North Sea markets to **seven to nine years** in Mediterranean countries, creating multi-year gaps between project conception and construction that erode investment returns and delay capacity additions (WindEurope, 2024).

Region	Average Permitting Time	Key Obstacle	Red III Goal
North Sea (DE, DK, NL)	3–5 years	Environmental Impact Assessments	Under 2 years
United Kingdom	4–6 years	Planning & Grid Consent Queues	Streamlined
Mediterranean (IT, ES, FR)	7–9 years	Administrative Overlap	Renewable go-to-Areas

The revised Renewable Energy Directive (RED III) and the EU's Industrial Accelerator Act aim to designate "go-to areas" for renewables where streamlined approvals apply, with a target of halving current timelines. However, implementation across 27 member states remains uneven, and Maritime Spatial Planning conflicts (including military exclusion zones that restrict up to 30% of available sea area in some regions), present obstacles that regulatory reform alone cannot resolve (European Commission, 2023a).

Grid Capacity: The Strategic Wall

Even where permits are secured, grid connection has emerged as a parallel and equally serious bottleneck. Connection wait times across major North Sea hubs currently range from **four to ten years**, driven by three compounding infrastructure failures.

1

Constraint 1: Queue Backlogs

Current wait times for grid connection across major North Sea hubs range from 4 to 10 years. National TSOs are operating on legacy radial connections rather than integrated meshed networks required to absorb large-scale variable generation.

2

Constraint 2: HVDC Maturity

Prevents interoperability between different turbine and converter manufacturers, creating unique connection requirements for each project.

3

Constraint 3: Ageing Infrastructure

Approximately 30% of EU's distribution grids are over 40 years old and will require full-scale replacement rather than incremental upgrades (European Commission, 2024).

Addressing these failures requires an estimated **€584 billion in EU grid investment by 2030**. A figure that highlights the scale of the challenge and the degree to which grid expansion has become as strategically important as turbine deployment itself (European Commission, 2024).



The scale of grid investment required is not merely a financial challenge but also reflects a deeper structural misalignment between the pace at which offshore wind capacity is being consented and the pace at which the transmission infrastructure to absorb it can be built. Until grid expansion catches up with generation ambition, even well-capitalized and fully permitted projects face the risk of being stranded at the point of connection. This infrastructure gap compounds the financial pressures already embedded in offshore wind development, where the cost of capital, raw materials, and installation have all risen materially since the low-rate environment in which much of the current pipeline was originally underwritten.

Financial Constraints: CAPEX and LCOE

Offshore wind is a capital-intensive asset class. Total project costs currently range from **€3,000 to €9,100 per kilowatt** depending on water depth, distance to shore, and local supply chain conditions. Each megawatt of installed capacity requires approximately **15 tonnes of critical minerals**, and foundation and installation costs alone account for **35% of total CAPEX** (IRENA, 2025). Rising financing costs have compounded these pressures: higher interest rates since 2021 have added **15–20% to effective project costs** compared to the low-rate environment in which many development pipelines were originally underwritten (IRENA, 2025).

The Levelized Cost of Energy (LCOE) is the average, net-present cost of generating one megawatt-hour (MWh) of electricity over a project's lifetime. It is the primary metric through which cost pressures can translate into investment decisions. Current LCOE ranges across the European markets and reflect both the maturity of supply chains and overall complexity of each individual project.

LCOE by Region in Europe

Market	LCOE Min (€/MWh)	LCOE Max (€/MWh)
Denmark	€56	€102
Germany	€62	€109
Netherlands	€55	€120
France	€114	€170
Floating Wind	€180	€230

The wide ranges within individual markets reflect the degree to which project-specific factors such as: grid connection distance, seabed conditions, and supply chain access, can impact economics significantly. Floating wind remains structurally more expensive than fixed-bottom due to the immaturity of its supply chain, but cost reduction trajectories suggest it will become increasingly competitive through the 2030s.

Supply Chain Scarcity and Ports Gap

The offshore wind supply chain is operating at or beyond capacity across multiple critical dimensions simultaneously. Installation vessel availability represents perhaps the most acute near-term constraint: the current global fleet cannot handle the 15 MW or larger turbines that are now the industry standard, and new vessel construction lead times exceed five years. Port infrastructure presents a parallel challenge, with most existing European facilities lacking the quay-load capacity required to assemble next-generation components. Subsea cable lead times now exceed **36 months**, creating scheduling conflicts that cascade across project timelines.

Component	Required Expansion	Key Issue
Installation Vessels	+15–20 heavy lift vessels	Lack of yards, current fleet cannot handle 15MW+ turbines
Port Infrastructure	€6.5 billion investment	Ports lack quay-load capacity (30+t/m ²) for assembly
Cable Production	4x manufacturing capacity	Lead times for subsea cables now exceed 36 months
VET Workforce	235 distinct job profiles	80% of critical roles rely on vocational training currently in decline

Underlying all these constraints is a workforce gap that is frequently underestimated. Approximately **80% of critical offshore wind roles** depend on vocational and technical training pipelines that are currently insufficient to meet projected demand (WindEurope, 2025).

Storage & Intermittency

The scaling of offshore wind creates a system-level challenge that goes beyond generation capacity: the need for long-duration storage to manage periods of low wind and solar output (known in German as *Dunkelflaute*) that can extend for days or weeks. Current lithium-ion battery technology is limited to approximately **four hours of discharge duration**, which is insufficient to bridge extended low-generation periods (IEA, 2024). Scaling longer-duration alternatives, including solid oxide hydrogen systems, iron-air batteries, and flow storage, requires both significant R&D investment and policy frameworks that reward duration rather than response speed alone (IEA, 2024).

The investment requirements to address storage and grid constraints through 2040 are substantial and span multiple infrastructure categories.

European Investment Requirements through 2040

Investment Area	Required by 2040	Current Annual Gap	Primary Constraint
Distribution Grids	€730 Billion	~€25 billion	Regulatory Scrap scrutiny
Transmission Grids	€477 Billion	~€15 billion	Permitting Delays (10+ years)
Offshore Infrastructure	€350 Billion	~€10 billion	Port Readiness & Supply Chain
Anticipatory Works	€50+ Billion	N/A (New Pilot)	Risk Allocation Frameworks

Hydrogen Integration

Green hydrogen has been positioned as a critical solution for hard-to-electrify sectors and as a mechanism for absorbing surplus offshore wind generation. In practice, however, the infrastructure required to produce, store, and transport hydrogen at scale has introduced its own set of constraints.

- **Supply Side Constraints:** Land and renewable resources are limiting domestic electrolysis. By 2040, Europe will likely face a **60% deficit in green hydrogen targets**, necessitating large scale imports from regions with higher irradiation (IEA, 2024)
- **Infrastructure Intricacies:** Repurposing natural gas pipelines involves long lead times and significant investments in liquefaction. High system costs such as: Power-to-Gas-to-Power conversion, remains a hurdle for hydrogen as a storage medium, at scale.

The Triple Threat Bottlenecks of 2040

Looking beyond the immediate 2024–2030 window, three structural constraints converge into what can be described as a triple-threat bottleneck. A compounding crisis in which raw material scarcity, logistical limits, and a skills deficit reinforce one another to constrain the pace of the energy transition.

Raw Material Scaling Crisis

Demand for rare earth elements that are required for offshore wind turbine technology is set to dramatically increase.

1

- **Rare Earth Metals:** projected up to 31x increase in Praseodymium demand specifically for offshore magnets (European Commission, 2023b)
- **Copper:** 1.0 Mt required for cabling alone; global supply gap projected to exceed 5 Mt/year by 2040 (European Commission, 2023b)
- **Steel & Iron:** Over 250 million tonnes required for foundations and structures (European Commission, 2023b)

With the concentration of rare earth metal processing currently in China, this creates a secondary geopolitical dependency that extends beyond the immediate supply chain constraints.

The Logistics Walls

Meeting EU offshore wind targets requires a fleet expansion of four to six new installation vessels per year through 2040 (Kuehne Climate Centre, 2024). Current Wind Turbine Installation Vessels (WTIVs) are dimensionally incapable of installing the 250-metre-plus rotor diameters of next-generation turbines, and the annual investment required to address this outside China is estimated at **€2.5–4.0 billion**. Without immediate newbuild orders, non-Chinese fleets are projected to support only **35% of planned offshore capacity by 2040** (Kuehne Climate Centre, 2024).

2

The Human Capital Roadblock

The workforce dimension of this bottleneck is already visible in project delivery. An estimated **two million additional specialised green jobs** will be required across the EU by 2050, and 96% of EU industry stakeholders identify the workforce gap as a current constraint rather than a future risk (WindEurope, 2025). Technical skills for variable renewable energy integration and smart grid management are currently lacking in **71% of the existing energy workforce**, while regulatory barriers to cross-border labour certification prevent the efficient deployment of specialists across member states.

3

Sustainability Gaps

This section examines sustainability gaps across the offshore wind industry using the Global Reporting Initiative (GRI) Standards as the analytical framework. GRI was selected because it is the most widely adopted reporting standard among global energy companies, including both Ørsted and TotalEnergies, and its topic-based structure maps directly onto the material issues that large-scale offshore wind development raises: climate, biodiversity, people, and supply chain integrity (Global Reporting Initiative [GRI], 2021). No sector-specific standard for offshore wind currently exists, so this analysis draws on the cross-sector GRI topics most relevant to the industry. As CSRD and IFRS S2 obligations come into force for large European companies from 2025 onwards, this framework should be revisited in future reporting cycles.

Item	Industry Best Practices and Emerging Trends
Climate	<ul style="list-style-type: none">• Disclosing the total carbon footprint of the supply chain, specifically focusing on the high-intensity emissions from steel and cement production and vessel operations.• Leading developers require Environmental Product Declarations (EPDs) from turbine OEMs to evaluate the "Green Steel" content of components.
Biodiversity	<ul style="list-style-type: none">• Implementing advanced technologies such as bubble curtains or dampened pile driving to minimize acoustic disturbance to marine mammals and fish. Strict decibel limits for pile driving are now legally mandated in North Sea jurisdictions, driving rapid adoption of noise-reduction innovations (WindEurope, 2025).• Utilizing AI-driven sensors and automated shutdown systems to monitor and mitigate the risk of bird strikes, particularly for migratory species.
Circularity	<ul style="list-style-type: none">• Establishing verified recycling pathways for composite blades to comply with regional bans on landfilling turbine components.• Designing for disassembly and ensuring that financial and logistical plans for resource recovery are established at the start of the project.
Supply Chain	<ul style="list-style-type: none">• Ensuring ethical and environmental compliance in sourcing materials like neodymium and balsa wood, while maintaining a highly resilient supply chain against geopolitical disruptions.• Implementing rigorous auditing and traceability mechanisms to identify and eliminate forced labour risks in the extraction of critical minerals (e.g., rare earths). The EU's Corporate Sustainability Due Diligence Directive (CSDDD) is forcing deeper transparency, extending audits to Tier 2 and Tier 3 suppliers (European Commission, 2024b).

Future Scenarios

The European wind energy sector is at a strategic inflection point, after periods of cost inflation, supply chain disruption, and policy uncertainty. We are now seeing the sector move towards a disciplined, Europe-first growth model. This analysis will further investigate these constraints and review what possible scenarios may be.

Scenario Framework

Effective scenario analysis requires axes that are (a) genuinely uncertain over the planning horizon, (b) materially consequential for business outcomes, and (c) as independent from each other as possible. We have proposed setting the axes as the **policy environment** and **supply chain resilience**, as these two factors represent dominant uncertainties shaping European offshore wind deployment through 2040.

Policy and Permitting Environment

The gap between stated political ambition and actual delivery capacity remains a defining tension in European wind. The EU's REPowerEU plan targets **510 GW of wind by 2030**, roughly doubling current capacity in under six years (European Commission, 2022). Yet permitting timelines in Germany, Poland, and the UK regularly exceed 7–10 years for many of the major offshore projects. While grid connection bottlenecks, public opposition, and environmental review complexities create continued structural constraints.

Mainly, will the EU's permitting reforms, and grid investment mandate be implemented in a timely manner and effectively at scale, will the execution fall short.

Supply Chain Resilience

Supply chain constraints have emerged as an equally problematic bottleneck alongside policy. Between 2021 and 2024, turbine prices increased by ~40%, installation vessel day-rates more than doubled, and critical raw material costs (steel, rare earth elements, copper) became structurally elevated (IRENA, 2025; WindEurope, 2025). The key uncertainty for 2040 is whether European offshore wind can build a resilient, cost-competitive domestic supply chain. Otherwise, supply scarcity will continue to constrain deployment volumes and project costs will inflate.

In these scenarios, both axes are distinctly individual, as a developer can hold all necessary permits, but still be unable to build if the materials themselves are not available.

Why not use Cost/LCOE as an axis?

While it may feel like the obvious choice for a scenario axis to be Cost/LCOE, a common focus in business decisions, this axis would not be independent of the other variables. Cost should be treated as an **output of policy and supply chain** rather than an independent variable. When policy is strong, and supply chains are resilient, then LCOE falls naturally; when either variable is constrained, costs rise.

The Scenario Matrix

Figure 2 presents the 2x2 scenario matrix. The vertical axis reflects the policy and permitting environment (from weak/fragmented to strong/coordinated). The horizontal axis reflects supply chain resilience (from constrained/disrupted to resilient/recovered). The four resulting scenarios show the possible outcome space for European wind energy through 2040 and carry strategic implications for Ørsted and TotalEnergies.

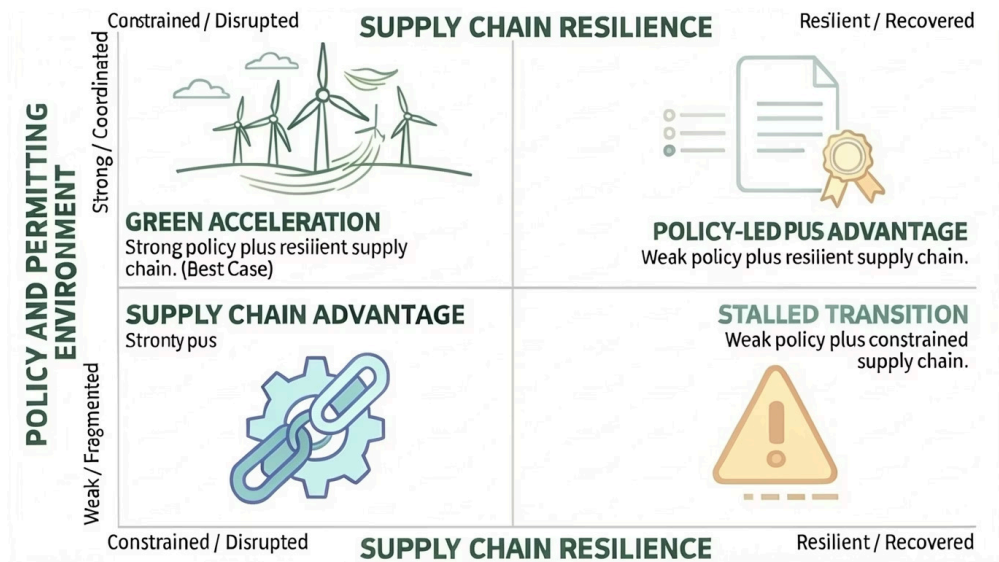


Figure 2: Proposed 2x2 Scenario Matrix: Policy Environment x Supply Chain Resilience (2025–2040).

Scenario Probability Weightings

The following probability weightings are qualitative estimates based on a structured review of current market conditions across two axes: policy momentum and supply chain recovery trajectories. They are not derived from a formal probabilistic model but rather reflect the analytical judgment of this report's authors, informed by publicly available industry forecasts from WindEurope, the IEA World Energy Outlook 2024, and the European Commission's REPowerEU progress reports. Weightings were assigned by first anchoring on the most likely base case, then distributing residual probability across the remaining scenarios in proportion to their plausibility given current evidence.

Scenario	Probability	Key Swing Factor
Green Acceleration	25–30%	EU permitting reform delivered at scale; supply chain fully recovers post-2026
Supply Chain Advantage	20–25%	Policy stalls but vertically integrated developers exploit component scarcity
Policy-Led Push	30–35%	Most likely base case: reform succeeds but turbine/vessel bottlenecks persist
Stalled Transition	10–15%	Political fragmentation blocks reform; supply chain does not recover before 2032

These weightings should be treated as directional rather than precise. The probability ranges reflect genuine uncertainty, and scenarios should be revisited as policy reform progresses and supply chain conditions evolve post-2026. Based on where the EU is currently, it is anticipated that a policy-led push will be the most likely outcome, consistent with permitting reforms that are said to be implemented soon. These should help streamline permitting processes, but supply chain will remain a constraint through the next 5+ years.

Scenario Analysis: Four Paths to 2040

Scenario 1: Green Acceleration (25–30%)

Both policy reform and supply chain recovery deliver — wind becomes the backbone of the European power network.

Macro Conditions: Permitting timelines fall below three years in core markets (UK, Germany, Netherlands, Denmark), achieved through dedicated fast-track zones, digital permitting platforms, and reformed environmental review processes aligned with the EU's Emergency Permitting Regulation (European Commission, 2023a). The European offshore wind supply chain undergoes structural recovery. Turbine manufacturers return to profitability and can begin scaling next-generation 20+ MW offshore platforms. A new wave of European-built installation vessels, supported by strategic public investment in port infrastructure. Raw material supply chains are diversified away from single-country dependencies, and domestic material resources expand. LCOE for offshore wind returns to a declining trajectory.

Ørsted: Hornsea 3 (2.9 GW) and Borkum Riffgrund 3 (900 MW) commissioned on schedule and profitable. Offshore EBITDA margins return to 38–45%; scale advantages over new market entrants maintained. Competitive CfD strike prices on new UK contracts. Leverage procurement scale to lock in long-term turbine and vessel contracts.

TotalEnergies: Full 7.5 GW German North Sea hub developed on/ahead of schedule. Floating wind Culzean pilot moves to commercial demonstration. CPPA pricing power increases; integrated clean power packages commanding premiums. Electricity segment approaches 100 TWh target by 2030.

Competitive Risk: Chinese developers (Ming Yang, CSSC) enter European auction markets with structurally lower cost bases. Ørsted must achieve LCOE leadership to defend market share. TotalEnergies less exposed to Chinese competition due to integrated model; risk is underinvestment relative to opportunity if oil/gas returns strengthen board attention.

Scenario 2: Supply Chain Advantage (20–25%)

Supply chains recover but permitting bottlenecks mean only developers with the strongest procurement positions can build.

Macro Conditions: The European offshore wind supply chain undergoes a strong recovery, turbine prices fall, and port infrastructure expands, but political permitting reform fails to deliver at the scale envisioned. EU struggles to implement fast-track permitting in practice, blocked by a combination of public opposition, legal challenges, and interministerial coordination failures. Permitting timelines remain above five years in most markets. Projects that can secure permits and grid connections are extremely profitable because supply chains are competitive and demand for wind capacity is high — creating a competitive landscape where procurement capability and permitting relationships determine who builds.

Ørsted: Permitting relationships in UK, Denmark, Germany provide preferential access to limited permit slots. Ørsted's 30-year government relationships become a competitive advantage. Scarcity premiums on contracted capacity generate CfD windfall returns. Merchant exposure on operational assets benefits from tight market pricing.

TotalEnergies: German hub progress slowed by permitting; Danish and Nordic projects face delays. Floating wind lease positions maintained but not yet developable. Strong CPPA pricing as industrial customers compete for limited renewable supply. Gas trading benefits from tight power market.

Competitive Risk: Chinese offshore developers lack European permitting relationships. Near-term competitive threat lower than in Green Acceleration scenario. TotalEnergies' diversified model less penalised by constrained volume; risk is missing the recovery opportunity if capital is deployed in oil/gas at the expense of wind pipeline investment.

Scenario Analysis: Four Paths to 2040 cont.

Scenario 3: Policy-Led Push (30–35%) — Most Likely Base Case

Policy reforms unlock pipelines, but turbine and vessel scarcity become the limiting factors in terms of how quickly projects can be deployed.

Macro Conditions: This is the most likely scenario based on current trajectory. Permitting and grid reform delivers acceleration of approvals from 2026 onwards, with the EU's Emergency Permitting Regulation reducing timelines by 30–40% in core markets by 2030 (European Commission, 2023a). Supply chain constraints remain persistent. Installation vessel capacity cannot scale fast enough to meet approved project volumes. Turbine delivery queues lengthen as manufacturers prioritize most profitable markets. Port infrastructure bottlenecks in Germany, Poland, and the Baltics further constrain installation rates. The net effect is a market with more consented projects than can be physically built on any given timeline: the constraint shifts from permitting to physical execution capacity. CfD auction prices are competed down aggressively, compressing margins even as volumes grow.

Ørsted: High consented pipeline volume but supply chain limitations force sequencing decisions. Construction program must be carefully phased to avoid vessel and turbine conflicts across projects. Competitive CfD strike prices on new UK contracts. Renewable oversupply lowers spot prices, and makes cost reduction programs essential. Storage and grid balancing services growing in importance as supply-side saturation creates everyday energy price volatility. Early framework agreements with installation vessel operators becomes competitive differentiator.

TotalEnergies: German hub construction sequenced carefully to avoid vessel conflicts. Selective development of Danish and Nordic projects to manage execution capacity. 7.5 GW hub scale creates negotiating power despite market tightness. Explore hydrogen offtake to lock in demand.

Competitive Risk: Chinese offshore developers entering with supply chain advantages (domestic vessel capacity, turbine manufacturing scale) represent the medium-term threat to European auction competitiveness. TotalEnergies' integrated model more defensible than pure-play wind in profit-compressed environment; gas trading provides revenue cushion.

Scenario 4: Stalled Transition (10–15%)

Political framework blocks permitting reform while supply chain disruptions prevent the projects that are approved from being built.

Macro Conditions: This worst-case scenario combines lack of political reform with extreme supply chain constraints. Permitting reform initiatives are diluted through a combination of political opposition — timelines remain above seven years in Germany and show little improvement across the rest of Europe. Supply chain constraints persist and worsen. Geopolitical tensions disrupt raw mineral supply chains (China accounts for ~90% of global rare earth processing). European vessel construction programs are delayed by shipyard capacity constraints, and turbine manufacturers face renewed margin pressure from price spikes. The combination of high development costs, long lead times, and insufficient auction volumes causes a wave of project cancellations and developer retreats from auctions. This is a dynamic already visible in Ørsted's cancellation of Hornsea 4 (2.4 GW) in 2025 and TotalEnergies' suspension of the US Attentive Energy project (Ørsted A/S, 2025a; TotalEnergies SE, 2025).

Ørsted: Major deferrals and cancellations inevitable beyond committed construction portfolio. Ørsted focused on completing 8.1 GW under-construction pipeline without new FIDs. Operational CfD assets generate stable contracted income; new contracted additions limited. No new procurement commitments; existing framework agreements renegotiated to reduce volume obligations.

TotalEnergies: German hub selectively continued for highest-return projects only. Danish and Nordic projects deferred. Floating wind assets become long-term option rather than active development. Oil/gas sustains overall financial performance; wind EBITDA contribution reduces as new contracted additions are limited.

Competitive Risk: Ørsted faces financial distress risk creating M&A vulnerability as balance sheet pressure may force asset sales at cyclically low valuations. The priority is maintaining investment-grade credit ratings through capital preservation and intensive lobbying for policy intervention. A rights issue or emergency farm-down may be required if the scenario persists beyond 2028. TotalEnergies' balance sheet strength creates new M&A opportunities to acquire distressed developer assets and pre-permitted project pipeline at below-cycle valuations.

Ørsted: Winning Through Execution Leadership

Ørsted enters the 2025–2040 period as the world's leading offshore wind developer by installed capacity and institutional depth, but one that has recently completed a significant strategic reset. Following the cancellation of US projects including Hornsea 4 and a DKK 60 billion rights issue to stabilise the balance sheet (Ørsted A/S, 2025a), the company has re-anchored to its European heartland, where its structural advantages are most durable and its competitive moat is widest.

Ørsted's core competitive advantage lies not in its balance sheet, but in its **thirty-year operating history in European offshore wind**: deep regulatory relationships, permitting expertise, and project execution experience accumulated across eight jurisdictions. Under the most likely scenario, Policy-Led Push, where execution capacity rather than project access becomes the binding constraint, these capabilities represent a structural advantage that is difficult for new entrants to replicate (Ørsted A/S, 2025a). The strategic imperative is therefore to transition from a first-mover developer into an execution-focused industrial operator: delivering projects faster, more reliably, and at lower cost than any competitor.

Pipeline Execution

Ørsted's pipeline strategy must shift from prioritising individual flagship projects toward optimising total portfolio throughput across a sequenced, diversified programme. In a market where vessel and turbine availability constrain how many projects can be simultaneously constructed, the company that sequences its pipeline most efficiently will deliver more megawatts per year than the company with the largest individual project.

The near-term priority is the reliable commissioning of **Hornsea 3 (2.9 GW, UK)** and **Borkum Riffgrund 3 (900 MW, Germany)**, the two anchor projects that will define Ørsted's margin profile through 2030 and demonstrate to the market that large-scale offshore wind can be delivered on schedule and at contracted economics after the turbulence of 2022–2025. Beyond these committed projects, Ørsted should formalise a standardised, repeatable development model across all stages of offshore wind deployment, from permitting and design through construction and operations. By systematising its European project history into documented, transferable workflows, the company can compress development timelines on new bids, reduce execution risk, and multiply project count across northern and central European markets.

Rather than concentrating solely on very large-scale projects, Ørsted should also optimise for mid-sized, lower-risk projects, particularly in the **400–800 MW range**, that can be delivered within existing supply chain constraints and that distribute impairment risk across a broader portfolio. Portfolio volume, not individual scale, becomes the instrument of resilience in a constrained execution environment.

Revenue & Margins

Ørsted's revenue model is heavily dependent on Contracts for Difference and competitive auction outcomes, making strike price levels the single most important driver of project-level returns. Under the Policy-Led Push scenario, CfD strike prices are competed down aggressively as permitting reform increases the supply of consented projects, compressing margins even as deployment volumes grow. Maintaining acceptable IRRs in this environment requires a relentless focus on LCOE reduction.

The recently announced DKK 1 billion cost efficiency program is a necessary first step, but the deeper prize is achieving structural LCOE leadership through standardization of project design, optimized construction logistics, and procurement at scale (Ørsted A/S, 2025a). A **100 basis point reduction in WACC**, achievable as the balance sheet is restored to investment-grade comfort, is estimated to improve offshore wind project IRRs by approximately 2–3 percentage points, making financial discipline as important as engineering efficiency.

On the revenue side, Ørsted should increase its exposure to long-term corporate Power Purchase Agreements alongside traditional CfD contracts, reducing sensitivity to auction price cycles while building direct relationships with European industrial customers whose decarbonization commitments create structural demand for firm, credibly-sourced renewable power. Farm-downs of operational assets to institutional investors, at premium valuations reflecting stable contracted cash flows, can recycle capital into the development pipeline without balance sheet stress.

Supply Chain Strategy

In the Policy-Led Push scenario, supply chain access is the primary competitive differentiator. The developer who has locked in turbine delivery slots and installation vessel availability will build; the developer who has not will wait. Ørsted's procurement scale, as the largest single buyer of offshore wind components in Europe, is its most powerful, and most under-utilized, competitive weapon.

Ørsted should establish long-term framework agreements with **Vestas, Siemens Gamesa Renewable Energy**, and the leading European installation vessel operators, covering multi-project volumes across its 2026–2032 construction program. These agreements should be structured to exchange volume commitment for price certainty and delivery priority, explicitly locking in the supply chain slots that smaller developers will be unable to secure. The value of these agreements increases non-linearly in constrained scenarios: in a market where five vessels are available and ten developers need them, the developer with a framework agreement wins by default.

Beyond turbines and vessels, Ørsted should invest in specialized port infrastructure co-investment, particularly in Germany and the UK, to ensure that assembly and staging capacity exists for its pipeline. The projected **€6.5 billion European port infrastructure gap** represents both a systemic risk and a first-mover opportunity: Ørsted's volume justifies port co-investment that smaller developers cannot contemplate, and port capacity secured now becomes a structural barrier to competitors in the mid-2030s. Sourcing of critical raw materials, including rare earths, copper, and structural steel, should be diversified across multiple geographies and supplier relationships, reducing single-country dependency risk consistent with the EU's Critical Raw Materials Act framework.

Competitive Risk

The most significant competitive threat to Ørsted's European position is not another European developer, it is the entry of **Chinese state-owned offshore wind developers**, including Ming Yang Smart Energy and CSSC Offshore, into European CfD auction markets. Chinese developers benefit from structurally lower cost bases through domestic turbine manufacturing scale, vertically integrated supply chains, and access to subsidized capital from state policy banks (WindEurope, 2025). Bids from these entities at European auctions could compress strike prices to levels that only the most cost-efficient European developers can sustain profitably.

Ørsted's defence against this threat cannot be cost alone, Chinese state capital enjoys structural cost advantages that private European developers cannot match through efficiency alone. The defence must be institutional: leveraging the permitting relationships, community trust, and regulatory track record that Chinese developers cannot replicate on any compressed timeline. In this respect, Ørsted's thirty years of European government relationships are not merely a historical asset, they are its primary competitive weapon against sovereign-backed competition.

At the same time, Ørsted should invest in **floating offshore wind** as a strategic hedge against commoditization of the fixed-bottom segment. Floating wind opens water depths of 60 meters or more, substantially expanding the addressable European market while creating a new technology cycle in which Ørsted's early-mover investment generates defensible position before new entrants establish presence.

Total Energies: Winning Through Integration

TotalEnergies approaches the offshore wind market from a fundamentally different position to Ørsted. As a publicly listed integrated energy major with revenues spanning LNG, power trading, storage, and renewables, wind is a critically important but not existential component of its portfolio. This structural difference is simultaneously the company's greatest competitive advantage and its most significant strategic risk: the integrated model provides resilience and capital flexibility that pure-play developers cannot match, but it also creates persistent internal pressure to allocate capital toward whichever asset class is generating the strongest near-term returns.

The most probably trajectory for European offshore wind through 2040 is a policy led push, constrained by supply chain execution. However, this plays to TotalEnergies' strengths. TotalEnergies should leverage its leading European integrated energy position to accelerate offshore wind pipeline execution through proactive public-private collaboration and strategic lobbying. Additionally, its emerging **7.5 GW German North Sea hub**, developed in partnership with RWE, represents one of the largest geographically concentrated offshore wind programs in Europe, creating procurement, logistics, and operations and maintenance synergies that dispersed project portfolios cannot replicate.

By securing long-term European supply partnerships, investing in logistics and digital optimization, TotalEnergies can mitigate the bottlenecks while differentiating itself from lower-cost competitors particularly Chinese developers. The company's ability to combine operational resilience, disciplined capital allocation, and integrated clean energy solutions will determine whether it can sustain profitability and secure long-term leadership in EU's offshore wind market through 2040.

Pipeline Execution

The primary constraint on TotalEnergies' pipeline is not capital, but the permitting and grid connection. Depending on the market, average permitting timelines range from three to nine years, and grid connection costs across Europe are estimated at **€584 billion through 2030**, making these inherently collaborative challenges that no single developer can resolve unilaterally (WindEurope, 2024).

TotalEnergies should effectively leverage its position as Europe's leading integrated energy company and actively lobby and strengthen its presence by attending international conferences, such as COP, to push governments to accelerate offshore wind development. Where permitting bottlenecks remain acute, joint ventures and co-development arrangements with local utilities reduce early-stage capital exposure while maintaining strategic option value on development positions.

The German North Sea hub should also be treated as the pipeline's organisational anchor. Concentrating 7.5 GW of work within a defined geography creates shared development infrastructure that allows the construction program to be sequenced efficiently across the 2026–2034 build window. Danish and Nordic development positions provide geographic diversification and exposure to markets with comparatively streamlined permitting frameworks. Where projects in these markets face delays, the priority should be maintaining option value rather than committing capital ahead of permit certainty.

Revenue and Margins

As a publicly listed company, TotalEnergies must demonstrate credible returns on its offshore wind portfolio against competing capital allocation opportunities within the group. Five interconnected strategies address different dimensions of margin protection and cash flow stability in a market characterized by rising volume but compressing spot prices.

1 CAPEX Optimization through Scale
Wind turbine scale-up increases the output per turbine, which reduces the total number of units required to achieve the same power capacity. This lowers foundation installation costs and the total length of subsea cables, thereby reducing the construction unit cost per MW. Additionally, the German hub's 7.5 GW volume creates procurement leverage that smaller developers cannot access. Long-term supply agreements with turbine manufacturers, locked in ahead of the next demand surge, eliminate the cost inflation risk that damaged project economics across the sector between 2021 and 2024 (IRENA, 2025).

2 OPEX Efficiency through Clustering
Unlike onshore projects, offshore wind incurs significant accessibility costs for operations and maintenance, including transportation via specialist vessels and helicopters. By operating multiple projects in close geographic proximity across European countries, TotalEnergies can share O&M bases, reduce vessel mobilization costs, and standardize maintenance workflows across the hub. Leveraging AI-driven data analytics, which is currently being deployed across TotalEnergies' assets, enables predictive maintenance, targeting specific issues precisely before severe damage occurs, and incurs massive repair costs.

3 Long-Term Power Purchase Agreements
TotalEnergies can enter direct, long-term (10 to 20 years) fixed-price power agreements with major manufacturing companies to support their defense against wholesale prices. The long-term fixed-price contracts of 10-20 years with major technology companies and energy-intensive industrial users provide revenue certainty supporting project economics from price volatility. TotalEnergies' investment-grade credit rating and brand strength as a financially stable integrated major give it a negotiating advantage over smaller renewable-only developers when competing for anchor PPA offtake (TotalEnergies SE, 2025). Gaining synergy by combining offshore wind with energy storage systems (ESS) and green hydrogen, areas that are also part of TotalEnergies' Integrated Energy segment.

4 Capital Recycling
TotalEnergies can advance projects through the high-risk early development phases and, once value has been created through permit awards or auction wins, sell down equity stakes to institutional investors at a premium. This model improves capital efficiency, allowing the same capital to be redeployed into subsequent development projects without additional balance sheet commitment. It is already well-established in the European offshore wind market and is particularly well-suited to TotalEnergies' project financing flexibility as a private-sector company with no obligation to reflect government capital allocation mandates.

5 Portfolio Resilience through Diversification
If conditions shift toward the Stalled Transition scenario, TotalEnergies' diversified portfolio, which includes spanning LNG, gas trading, oil, renewables, and storage, provides a structural buffer that pure-play wind developers do not possess. Maintaining current capital allocation discipline and avoiding over-concentration in offshore wind at the expense of the cash-generating assets that fund long-term renewable investment, is not a fallback position. It is the mechanism that allows TotalEnergies to invest counter-cyclically in offshore wind during periods when pure-play developers are constrained.

Supply Chain Strategy

TotalEnergies' supply chain strategy must address the same fundamental bottleneck as Ørsted's — turbine delivery, vessel availability, port capacity, and critical raw materials — but from the distinct position of a developer whose 7.5 GW German hub concentration creates both unique leverage and unique vulnerability. If the hub's supply chain is disrupted, the impact is concentrated rather than diversified across multiple markets.

The company should establish long-term framework agreements with European turbine manufacturers, subsea cable producers, and installation vessel operators, anchored by the volume commitment that the German hub represents. These agreements should prioritize European-sourced supply wherever practicable, not primarily as an ethical posture, but as a regulatory hedge that aligns TotalEnergies with the EU's evolving industrial policy at precisely the moment European governments are most receptive to domestic supply chain champions. The EU's Net-Zero Industry Act and Critical Raw Materials Act create a policy environment in which companies demonstrating European supply chain investment gain preferential regulatory treatment (European Commission, 2024c; European Commission, 2023b).

Port infrastructure co-investment, particularly at **Rotterdam, Hamburg, and Bremerhaven**, should be pursued through public-private partnership structures that share capital cost and construction risk with government and logistics partners while securing long-term operational priority for TotalEnergies' project program. The projected €6.5 billion European port infrastructure gap means that developers who co-invest in port capacity now are securing execution capability that will be unavailable at any price in the mid-2030s (WindEurope, 2025).

On critical raw materials, TotalEnergies should diversify sourcing partnerships across multiple geographies, reducing reliance on Chinese rare earth processing and single-source copper supply, while investing in circular supply chain initiatives for turbine materials and battery storage components. The EU's Corporate Sustainability Due Diligence Directive increasingly requires this transparency from Tier 2 and Tier 3 suppliers (European Commission, 2024b), and early investment in supply chain traceability creates both compliance resilience and reputational advantage.

TotalEnergies should also explore equity investment in European turbine manufacturers and installation vessel operators, building the supply chain equity stakes that provide priority access in constrained scenarios while generating returns that partially offset the CAPEX burden of the investments themselves.

Competitive Risk

TotalEnergies faces competitive pressure from three distinct vectors: established European offshore wind specialists (led by Ørsted), emerging Chinese state-backed developers, and the broader universe of integrated energy majors, including BP, Shell, and Equinor, that are building European renewable portfolios (WindEurope, 2025). Of these, the Chinese entry risk is structurally most significant: state-backed developers with access to subsidized capital and domestically manufactured turbines can submit CfD bids at prices that challenge the economics of European-sourced projects.

TotalEnergies' defense against this competitive pressure should operate on two levels. At the project level, the integrated energy offering, combining offshore wind generation with battery storage, grid balancing services, and long-term PPAs, creates a value proposition that Chinese developers offering electricity-only propositions cannot match. European industrial customers, subject to increasing corporate sustainability reporting obligations, are willing to pay a premium for the credibility and service depth that TotalEnergies' integrated model provides.

At the institutional level, TotalEnergies' European identity and supply chain investment position it well to benefit from the EU's evolving preference for domestic industrial champions over foreign state-owned enterprises in critical infrastructure. The company should actively cultivate regulatory relationships in **Berlin, Paris, Copenhagen, and Brussels**, framing its investment program explicitly in terms of European energy security and industrial policy, the language that resonates most powerfully with the governments whose permitting and grid connection decisions will determine which developers build and which wait.

The most significant internal competitive risk is **capital allocation drift**: in scenarios where LNG and oil trading margins outperform renewable returns, the internal pressure to redirect capital away from offshore wind investment will intensify. TotalEnergies should establish explicit, board-level commitments to minimum offshore wind investment levels that are maintained regardless of short-term commodity market conditions, protecting the long-term strategic build of renewable capabilities against the tactical logic of near-term return maximization (TotalEnergies SE, 2025).

Closing Out the Strategic Implications

The European offshore wind market through 2040 will not be won on ambition or policy alignment alone. It will be won on the capacity to execute. To move turbines, vessels, cables, and people into position faster and more reliably than any competitor. Ørsted and TotalEnergies both understand this, and both are structurally better positioned than almost any other developer to navigate what is coming. But they are positioned differently, and that difference matters. Ørsted's thirty years of European institutional relationships and its unmatched offshore execution depth make it the company most capable of delivering at volume in the markets that will matter most. TotalEnergies' integrated model, German hub concentration, and balance sheet resilience make it the company most capable of sustaining investment through the inevitable cycle of constraint and recovery. The offshore wind market does not need both companies to follow the same path. It needs Ørsted to execute, and it needs TotalEnergies to integrate. If both do what their competitive architectures were built to do, European offshore wind will have two of the most capable operators in the world helping to build the energy system that the continent needs by 2040.

Appendix I: About the Authors

While energy is the most vital and foundational element supporting our daily lives, it currently faces unprecedented crises, including rising demand and supply chain instabilities triggered by climate issues and conflicts in the Middle East. That is why, in our MBA program at SUMAS, we analyzed the European energy landscape to examine what strategies two of Europe's major energy companies, TotalEnergies and Ørsted, should adopt by leveraging offshore wind power, one of the key renewable energy infrastructures.

Vittoria Biscotti

Vittoria Biscotti is an MBA candidate with a background in electric vehicle charging infrastructure and sustainable energy systems. She previously worked as a project manager at Tesla, supporting large-scale charging network deployment across Canada, where she collaborated with utilities and public-sector partners on incentive programs, infrastructure planning, and network expansion strategies. Her work included developing financial models and evaluating site-level investments based on demand projections, policy frameworks, and cost considerations. Through her experience, she has developed a strong interest in energy transition strategy, renewable energy markets, and the scaling of low-carbon infrastructure. Her academic and professional focus centers on understanding how major energy players, such as Ørsted and TotalEnergies, can navigate growth and competitiveness in the evolving European wind energy landscape.

Tanya Joshi

Tanya Joshi is a master's candidate in Sustainable Fashion Management at SUMAS, Switzerland, with a background in fashion business, retail operations, and sustainability-focused brand development. She previously worked as Store Manager at Bombay Closet Cleanse, India's first thrift store, where she contributed to sustainable retail initiatives, merchandising strategy, and customer engagement. She also served as Fashion Consultant at Reliance Abraham & Thakore, managing retail operations, inventory systems, and customer experience strategy within the luxury fashion sector. Her professional interests center on sustainable fashion systems, brand management, consumer behavior, and the integration of sustainability into contemporary retail and merchandising practices. With an international academic background spanning Italy, Switzerland, and the United Kingdom, she is particularly interested in developing innovative strategies that combine sustainability, fashion, and cultural storytelling.

Swetha Karempudi

Swetha Karempudi is a masters candidate in Sustainable Fashion management at SUMAS, with a background in both Fashion Industry and IT, with experience as an Application Developer in Accenture contributing to development and maintenance of applications according to client needs. Also served as a Data Analyst in KVR Enterprises, responsible for data extraction and management, translating datasets and reporting. And has managed her personal small scale fashion brand-Stillvoll, managing business operations and designing new products according to customer requirements. Her professional interests' center in creating sustainable products and incorporating sustainability and circularity into developing her personal brand and the fashion industry.

Ayaka Sambe

Ayaka Sambe is an MBA candidate in Sustainable Management at SUMAS, with experience in project management of upstream energy sector. She was in charge of CCUS projects and project development in the U.S. Her interests include sustainable energy sourcing, energy security, circular economy.

Takeru Agawa

Takeru Agawa is an MBA candidate with a distinguished background spanning the Japanese banking sector across Japan, Southeast Asia, and Australia. He previously served as Chief Executive Officer of Singapore operations at a Japanese food oil company, where he led regional business development and cross-cultural management initiatives. His professional interests center on sustainable finance and the strategic integration of sustainability frameworks into Japanese corporate culture.

- We declare that this report, *The European Energy Mix and the Impact of Wind Energy through 2040*, was prepared independently by the undersigned students as a requirement of the MBA program at SUMAS Sustainability Management School. The work presented herein is our own and has not been submitted, in whole or in part, for assessment at any other institution or for any other purpose. All sources consulted in the preparation of this report have been acknowledged in accordance with APA 7th edition referencing conventions. Where the ideas, data, or analysis of others have been drawn upon, these have been appropriately cited. Any use of artificial intelligence tools in the drafting or editing process has been disclosed to the supervising faculty. We confirm that this report complies with SUMAS academic integrity policies and that we have not engaged in plagiarism, fabrication of data, or any other form of academic misconduct.

Vittoria Biscotti · Swetha Karempudi · Tanya Joshi · Ayaka Sambe · Takeru Agawa

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