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« The French marine renewable energy sector : from its early to its current ambitions »

According to the French Ministry for the Ecological Transition, marine renewable energies (MRE — EMR) encompass "the entire matrix of technologies enabling the generation of electricity from diverse resources available at sea: wind energy (offshore wind turbines), current energy (tidal stream turbines), tidal energy, wave energy (wave energy converters), and the temperature and salinity differentials between warm surface waters and deep cold waters (osmotic and ocean thermal energy)." Long after Northern Europe, France politically launched its deployment within this domain in 2007, yet only commissioned its very first commercial fixed-bottom offshore wind farm in 2023. The nation is henceforth heavily mobilized for this renewable energy, which directly responds to three paramount strategic challenges: achieving climate neutrality by 2050 to counter global climate change, electrifying the absolute entirety of energy uses, and securing a heightened national energy sovereignty.

Context and regional energy mix baselines

Officially, France's primary energy consumption stood at 2,571 TWh in 2020 (raw data uncorrected for climatic variations). The nation's actual primary energy mix is composed of 40% nuclear power, 28% oil, 16% natural gas, 14% renewable energies and waste, and 2% coal. To accelerate the transition, the State locked in a mandatory target of reaching 40% renewable energies within the gross final energy consumption by 2030.

Concurrently, the European Union continuously tightens its statutory objectives regarding carbon neutrality. Multilateral negotiations for the revision of the Renewable Energy Directive (RED III) culminated in a benchmark agreement: Member States established that the mandatory binding share of renewable energies to be utilized across the EU must hit 42.5% by 2030. The macro-development of marine renewable energies fits seamlessly within this European community framework, directly fulfilling the core climate mandates of the European Green Deal.

At sea, wind energy stands today as the most commercially mature sector on the marketplace, representing the highest potential for future large-scale energy generation¹. The kinetic energy of the wind—significantly stronger and more consistent at sea than ashore—is converted into electricity via offshore wind turbines, either fixed-bottom or, increasingly, floating architectures (*éolien flottant*). According to industry stakeholders, France benefits from the second-largest offshore wind resource potential in Europe, immediately following the United Kingdom.

To capitalize on this asset, space must be allocated; the State must therefore execute a sweeping spatial planning of its maritime façades (*planification des façades*), simultaneously balancing the protection of legacy traditional maritime activities, the deployment of green energies, and the strict preservation of the marine environment.

Sovereignly, Europe operates as the premier marketplace for offshore wind globally, and this green offshore industry is currently experiencing an immense boom across the EU. The Danish giant Ørsted (formerly DONG Energy), Germany's *E.ON Climate & Renewables*, and Sweden's Vattenfall stand as the dominant pioneer utilities managing offshore wind assets worldwide. Within the French utility landscape, legacy operators EDF Renouvelables and Engie (allied with *EDP Renewables* via their Ocean Winds joint venture) are being joined by TotalEnergies, which recently expanded its international portfolio by bidding on massive offshore wind tenders launched by the State of New York.

¹ Wave energy and tidal stream technologies remain at the experimental stage, while ocean thermal energy conversion (OTEC) is currently at the prototype phase. Although tidal stream energy benefits from strong resource potential across Brittany and Normandy, it has failed to structurally build a sustainable industrial supply chain over time.

In 2023, the cumulative capacity of active European offshore wind farms reached 34 GW, and an additional 31.4 GW is scheduled for grid connection between 2024 and 2030. The long-term macroeconomic ambitions are even more monumental: by 2050, the coastal nations bordering the North Sea project to deploy 300 GW of offshore capacity, while Baltic Sea states target a mid-term benchmark of 20 GW. A critical share of these regional ambitions will rely on Denmark's pioneering energy island hubs master projects, even though their precise construction calendars remain subject to macroeconomic uncertainties, mirroring identical maritime infrastructure initiatives underway in Belgium.

Structural bottlenecks confronting the European offshore industry

The territorial deployment of MRE infrastructures depends on a complex matrix of coexisting factors: including geographical constraints, subsea engineering techniques, macroeconomic viability, and volatile political and regulatory frameworks. Where do we stand within the EU? Despite the positive growth path observed historically, the European wind manufacturing supply chain currently collides with severe structural disruptions.

A high-level Communication released by the European Commission in October 2023 drafted a stark diagnostic, proposing immediate lines of action to rescue EU wind equipment manufacturers. The text isolates five major difficulties:

"First, the severe under-utilization of manufacturing capacities triggered by an insufficient and deeply uncertain domestic demand for wind turbines within the EU. Currently, industrial manufacturers completely lack an adequate, clear overview of the explicit deployment timelines planned by individual Member States, which severely complicates production planning, supply chain synchronization, and long-term capital investments."

Furthermore, the heavy logistics transportation of specialized wind turbine components and large parts mandates distinct special permits, which vary aggressively from one Member State to another, triggering severe bottlenecks and delays when moving assets from manufacturing sites to targeted offshore wind fields. This manufacturing under-utilization is equally driven by the chronic slowness and administrative complexity characterising the licensing and permitting procedures for renewable energy projects. (...) Second, vulnerable access to raw materials, soaring inflation, and high commodity prices. This landscape has been severely exacerbated by rising interest rates and compounding hurdles when accessing capital markets and project finance.

Third, the traditional design of national competitive tenders for renewable energy expansion frequently fails to appropriately reward the elevated environmental and social standards characteristic of European products, nor does it factor in the acute need for supply chain resilience, given that these sovereign auctions rely solely or predominantly on price criteria. (...).

Fourth, market pressure exerted by international competitors against the EU wind manufacturing supply chain has scaled up aggressively. (...).

Fifth, the structural availability of a highly skilled workforce across the wind manufacturing industry is liable to directly penalize the velocity required to ramp up European production capacities. Within the offshore wind segment in particular, qualified vessel captains, heavy-lift crane operators, and specialized technicians for heavy rigging operations are exceptionally difficult to recruit. Industrial corporations will urgently require a significantly higher headcount of workers, explicitly encompassing R&D engineers and skilled laborers. (...)."

The historic boom of global renewable energies was fundamentally secured by a massive collapse in pricing, most notably because mainland China supplies wind turbine components at heavily discounted rates. Within the wind energy cluster, nearly two out of three nacelles, blades, and tower masts worldwide are manufactured in China. Consequently, Chinese industrial giants such as Goldwind, Envision, and Mingyang are rapidly capturing market shares to the detriment of established Western leaders, namely Denmark's Vestas, the German-Spanish powerhouse Siemens Gamesa, and the American multinational General Electric (GE).

Beyond assembling components, the global wind industry is structurally dependent on secure access to critical raw materials, including copper, rare earth elements (REEs), electrical steel, nickel, fiberglass, and silicon. Western Europe relies entirely on third-party nations to secure its mineral supply chains—raw commodities whose demand is booming exponentially with the worldwide rollout of the sector, and whose prices remain highly volatile. Crucially, China controls 69% of global rare earth production, elements that remain absolutely vital for the engineering of high-performance permanent magnet generators inside modern offshore wind turbines.

Selected observers fear that European States are sliding into a greenfield era of structural energy dependence. The European Commission announced that it would launch a formal anti-subsidy investigation targeting Chinese wind turbine suppliers under the newly implemented Foreign Subventions Regulation (FSR). This high-level enforcement announcement materialized just as Chinese wind turbine manufacturers are successfully capturing substantial orders across the European territory. They deliver low-cost wind turbines backed by highly generous financing packages that directly distort the integrity of the European Single Market while disrupting fair competition. Statutorily, Chinese wind turbines are marketed in Europe at prices 20% to 50% lower than those manufactured by domestic European suppliers. Furthermore, their predatory deferred payment schemes mean, in reality, that Chinese manufacturers deliver their wind turbines completely free of charge until the offshore wind farm operator has successfully generated three full years of operational revenue. Crucially, European manufacturers are strictly prohibited from offering such aggressive payment deferrals under binding OECD export credit regulations.

Faced with this worrying diagnostic confronting the European wind cluster, the President of the European Commission, Ursula von der Leyen, formally announced the creation of a comprehensive European Wind Power Package to support European corporations within the sector and maximize their international competitiveness. This master action plan is articulated around six core operational pillars, engineered in tight coordination connecting the European Commission, individual Member States, and industrial stakeholders:

1. Accelerating deployment through heightened visibility and significantly faster permitting and licensing procedures.
2. Improving auction design across national competitive bidding frameworks.
3. Facilitating access to project finance and capital markets.
4. Enforcing a fair and competitive international environment.
5. Scaling up specialized skills and workforce vocational training.
6. Securing the deep commitment of the industry and Member States.

The concrete implementations of this master package encompass targeted regulatory overhauls: including binding measures under the revised Renewable Energy Directive (RED III) locking in the mandatory 42.5% green energy target by 2030, an emergency regulation streamlining permitting workflows, a comprehensive electricity market reform, and the *Green Deal Industrial Plan* which enforces the systematic integration of sustainability and supply chain resilience criteria within public procurement and sovereign auctions. It is concurrently backed by the mobilization of dedicated innovation funding channels, such as the *InvestEU* facility and *Horizon Europe* grants engineered to shield innovative SMEs.

Let us hope that it is not too late to reverse this geopolitical trajectory, and that the European wind turbine manufacturing supply chain will not suffer the identical catastrophic fate that previously decimated the domestic European solar photovoltaic industry.

Current and ongoing macro-projects in France

The pioneer commercial fixed-bottom offshore wind projects deployed off the French coastline are Saint-Nazaire (commissioned in 2022–2023), Fécamp (2024), and Saint-Brieuc (2024), aggregating 1.480 GW of low-carbon capacity—the electrical consumption equivalent of 500,000 households. The projects currently under active construction (fixed-bottom farms in Dunkirk, Dieppe-Le Tréport, Courseulles-sur-Mer, and Yeu-Noirmoutier, alongside floating pilot arrays in the Mediterranean) represent a cumulative capacity of 2.135 GW.

The sovereign Multi-Year Energy Programme, officially published on April 23, 2020, locks in multiple competitive tenders for the allocation of offshore wind projects over the coming years, targeting an additional capacity of 4.3 GW.

These projects are undergoing allocation, sustained by highly ambitious macro-objectives formalized by the Government, notably codified within the "Offshore Wind Pact between the State and the Industry Sector" (Pacte éolien en mer entre l'État et la filière) signed in March 2022. Under this binding industrial agreement, the State formally commits to targeting a minimum competitive tender allocation volume of 2 GW per year for offshore wind starting in 2025. It establishes a clear strategic trajectory: reaching 20 GW allocated by 2030, a capacity of 18 GW fully in service by 2035, and escalating to a monumental 45 GW by 2050.

Within the legal drafting framework of the updated PPE, the State has committed to executing comprehensive maritime spatial planning to seamlessly secure the attainment of these targets, while commercial tenders have identically been announced for tidal stream energy.

In return, the industrial sector commits to quadrupling its national headcount by 2035 to occupy at least 20,000 direct and indirect jobs across the territory, while unlocking over €40 billion in capital investments to realize ongoing projects over the next 15 years. Crucially, by 2035, developers must achieve a strict local content requirement of 50%, calculated on the entirety of the project's CAPEX at the exact moment of its commercial commissioning, for each individual offshore wind farm. Finally, the industry sector binds itself to implement exemplary projects regarding environmental protection and local social integration. By late 2024, four commercial fixed-bottom wind farms alongside three floating pilot arrays were under simultaneous construction off French shores. A historic record-breaking wave of capital investment was successfully executed to build these fields (turbines, substations, floating foundations) and deploy the associated subsea grid connections stemming from the initial national tenders. Currently, never had so many macro-projects been simultaneously under construction in France, translating mechanically into a €1.7 billion surge in the sector's global turnover over one year—attesting to the successful capture of these industrial markets by domestic corporate chains and the sharp export competitiveness of French companies².

Geographically, the Provence-Alpes-Côte d'Azur (PACA) region operated as the theater for a world-first technological innovation: the successful offshore installation of three wind turbines mounted onto state-of-the-art Tension-Leg Platform (TLP) floating foundations, commanding a unit capacity of 8.4 MW each—the electrical equivalent of the annual consumption of 45,000 inhabitants. These turbines belong to the pioneering Provence Grand Large (PGL) floating pilot wind farm, scheduled to achieve full grid connection and operational readiness by the end of this year.

Concurrently, the manufacturing of floating structures for the sister pilot farms—Éoliennes Flottantes du Golfe du Lion (EFGL) and EolMed—advanced rapidly across the specialized port industrial yards of Fos-sur-Mer and Port-La Nouvelle, respectively. Floating wind represents a first-rate technological disruption characterized by intensive industrial experimentation, positioning France as an undisputed global leader in the sector alongside Scotland and Portugal, which are identically testing these deepwater floating solutions.

This “Made in France” industrial experimentation is pre-engineered to foster the rise of a highly innovative domestic supply chain capable of being deployed both across the national territory and on international export markets, capitalizing on a paramount environmental asset: a substantially low footprint on the seabed, conversely to legacy fixed-bottom wind foundations. Blending these deepwater floating platforms with the offshore generation of green hydrogen represents a key avenue for the future. Sovereignly, the State did not integrate specific volumetric targets regarding the development of non-wind MRE technologies within the 2019–2028 PPE cycle, face to their current lack of commercial maturity. The PPE text indicates, however, that the government will remain highly attentive to the technical breakthroughs achieved by these alternative sectors. Moving along this path, the State formally announced its financial backing for the FloWatt pre-commercial tidal stream project, commanding a 17.5 MW capacity, slated to develop its hydro-kinetic array within the extreme, high-velocity currents of the Raz Blanchard corridor.

Port infrastructures and world-class offshore logistics hubs

France distinguishes itself from alternative nations by the massive volumes of capital investments planned across its national and regional port gateways. This trajectory encompasses the clustering of manufacturing plants (Montoir-de-Bretagne, Le Havre, Cherbourg)³ and heavy maritime infrastructure

² Among the key stakeholders involved in the development of offshore wind fields are specialized shipowners focused on marine subsea construction, heavy-lift operations, and maintenance logistics. A certified number of French shipping groups maintain a strong presence within this specialized value chain, notably LDA, TSM, Huchet Desmars, and Bourbon. Nevertheless, the absolute bulk of the heavy-lift offshore installation activity—including subsea cable-laying and turbine foundation positioning—remains heavily mastered by specialized maritime conglomerates originating from the Benelux countries and Scandinavia. Furthermore, acute social and labor law concerns have been raised regarding the utilization of alternative ship registries (*registres de libre immatriculation*) for purely domestic, territorial marine operations.

³ To this must be added the offshore electrical substation manufacturing facility operated by Chantiers de l'Atlantique in Saint-Nazaire.

upgrades. At the Port of Brest, outside the structural completion of its dedicated industrial polder, the port's public-private shareholders (the Brittany Region, Brest Métropole, and the Chamber of Commerce and Industry — CCI) signed a landmark agreement in 2023 to invest near €900 million over a forty-year timeline, strictly earmarked for energy transition blueprints, targeting to position Brest as a premier European hub for floating offshore wind logistics.

Concurrently, at Port-La-Nouvelle, a monumental envelope of €600 million is being injected between 2019 and 2026 to engineer the primary Mediterranean industrial sanctuary for floating wind assembly. Systematically, whenever an offshore project is deployed, the maritime sites undergo heavy custom engineering—such as the reinforcement of Cherbourg's heavy-load quayside—extending down to secondary ports optimized to host high-speed Crew Transfer Vessels (CTVs).

The Port of Nantes Saint-Nazaire commands immense industrial ambitions. Already, the deployment of France's very first offshore wind farm facilitated the engineering of a specialized €17 million logistics hub, which will be re-mobilized in 2025 to secure the marine installation of the Yeu-Noirmoutier offshore wind farm. To scale up operations, the GPM is developing a breakthrough project baptized "Éole". Engineered as a massive integration and staging base for next-generation floating wind turbines commanding a unit capacity of 20 to 25 MW, project *Éole* is pre-designed to meet the large-scale industrial requirements of the Atlantic façade (featuring 700 meters of heavy quayside, an operational draft of 12 to 14 meters, and three heavy mooring pontoons). Evaluated at €235 million, the infrastructure is slated for operational readiness by 2030.

On the Mediterranean range, across the Gulf of Fos—on a land plot originally safeguarded for container terminal expansions—the Grand Port Maritime de Marseille (GPMM) is launching a rival €550 million master project for floating wind integration, featuring a deepwater quay (17 to 20 meters draft) and a specialized mooring basin, strategically formatted to absorb Western Mediterranean industrial demand from 2028 onward.

MRE macro-development: Sustained public funding and EU frameworks

For over a decade, the French State has delivered an unwavering, structural support to accelerate MRE deployment, combining guaranteed feed-in tariffs for commercial offshore wind farms with robust R&D capital funding for non-wind alternative technologies. This continuous public commitment successfully fostered the emergence of a domestic industrial supply chain while positioning France among the global leaders in tidal stream and floating wind engineering. The *Investments for the Future Programme* (PIA) and the France 2030 master plan have continuously accompanied MRE innovations since 2010, driven notably by ADEME launching 5 highly targeted competitive calls for projects specifically tailored for tidal stream energy, wave energy converters, ocean thermal energy conversion (OTEC), floating wind arrays, and osmotic power.

³ *To this industrial matrix must be added the world-class offshore electrical substation manufacturing facility operated by Chantiers de l'Atlantique in Saint-Nazaire.*

On February 10, 2022, in Belfort, the President of the Republic officially announced a €1 billion public envelope under the France 2030 blueprint, specifically dedicated to financing innovation and supporting the manufacturing mass-scale industrialization of renewable energy equipment. At the supranational tier, Horizon Europe operates as the European Union's flagship framework programme for research and innovation spanning the 2021–2027 period, succeeding the legacy Horizon 2020 framework. This mechanism disposes of a monumental €95.5 billion central budget, representing an approximate 30% funding increase, establishing it as the most ambitious maritime and industrial MRE research and innovation funding pipeline worldwide.

Workforce dynamics, specialized skills, and the shadow of the US Inflation Reduction Act

The corporate ecosystem revolving around marine renewable energies is exceptionally broad, relying on top-tier technical skills within a highly dynamic cluster. It is driven concurrently by established global utilities (turbine manufacturers, energy conglomerates, historical offshore oil and gas engineering firms, mega-shipyards) and agile tech startups (notably specializing in innovative tidal turbine concepts, floating wind mooring systems, or composite floaters). Across Europe, the wind manufacturing supply chain (encompassing both onshore and offshore sectors) accounts for approximately 240,000 to 300,000 direct and indirect jobs within the EU. In France, by 2023, the active MRE sector aggregated

8,300 direct industrial jobs, a metric poised to expand exponentially face to the dense matrix of ongoing projects.

A severe structural shadow has nonetheless struck the sector: the wind energy branch of the American multinational General Electric (GE) Vernova implemented a drastic corporate restructuring plan, threatening 900 jobs worldwide. In France, this industrial retreat directly hits the Montoir-de-Bretagne assembly plant (Saint-Nazaire), where GE packages its *Haliade-X* offshore wind turbine nacelles, slashing the factory's workforce by an extreme 60%. The corporate drivers invoked by the American group center on severe market complexities, heavy losses recorded since 2015, and a strategic determination to streamline operations around a singular, standardized product portfolio.

Consequently, a profound anxiety grip local stakeholders: once current commercial order books are fully executed, GE might permanently relocate its offshore manufacturing machinery back to the United States, exiting France and Western Europe entirely. Geopolitical analysts estimate that the Inflation Reduction Act (IRA)—the Biden administration's monumental green industrial re-shoring legislation, injecting hundreds of billions of dollars in aggressive public subsidies and local content tax credits—is highly non-stranger to this strategic American corporate migration.

Ultimately, while the French MRE supply chain does not lack deeply motivated, high-velocity stakeholders (port authorities, State services, local collectivities, private corporations) and has successfully overcome the heavy infrastructure challenge, the core battle for long-term domestic industrialization remains exceptionally complex and fiercely contested on the global stage.

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