Global Offshore Low Carbon Energy Sector: Annual Market Intelligence Report 2025

EDITOR'S BRIEF

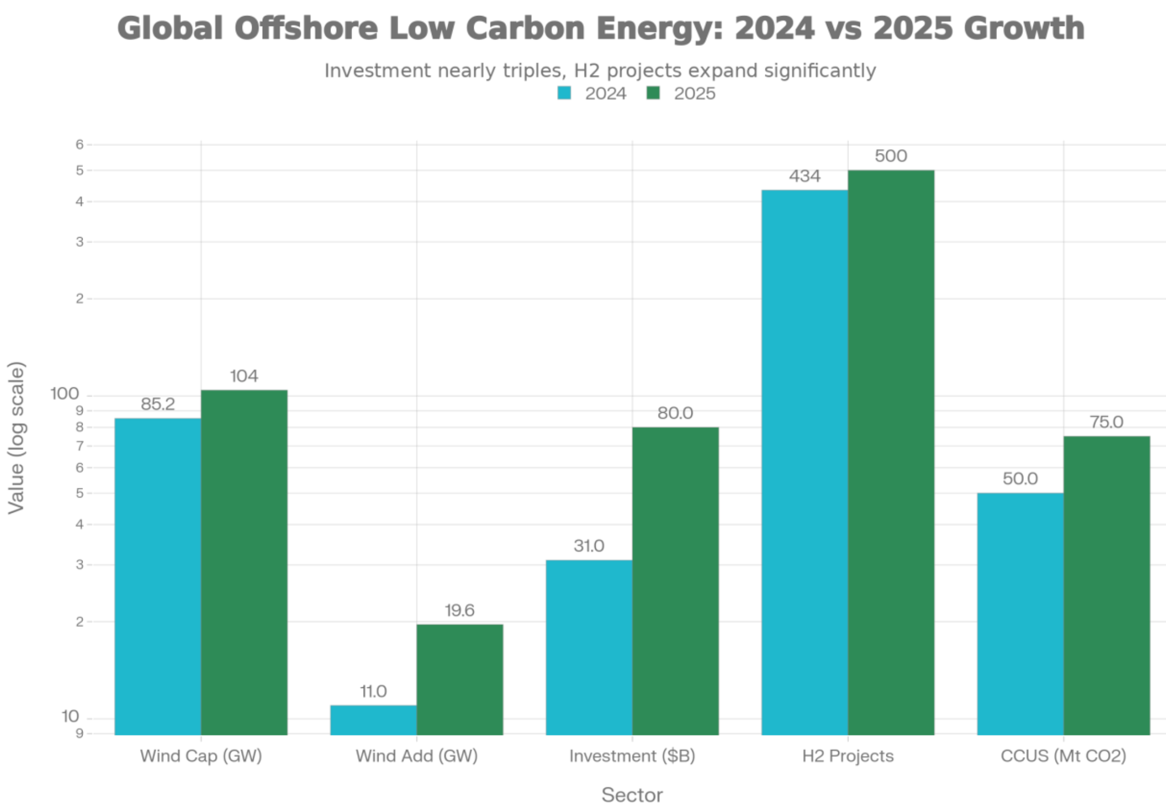
The global offshore low carbon energy sector achieved unprecedented momentum in 2025, with record capacity installations, surging investment, and accelerating policy support across multiple technology pathways. Despite persistent challenges including supply chain constraints, policy volatility in key markets, and cost pressures, the sector demonstrated remarkable resilience as governments and industry committed to decarbonization targets. Global offshore wind capacity reached 104.2 GW by year-end, clean hydrogen investment nearly doubled, and carbon capture infrastructure expanded significantly. This comprehensive review examines the major trends, regional developments, technology advances, investment flows, and policy frameworks that defined the offshore low carbon energy landscape in 2025.

Executive Overview: A Transformational Year for Offshore Energy

The year 2025 marked a pivotal turning point for the global offshore low carbon energy sector, characterized by record-breaking deployment, substantial investment growth, and deepening integration across renewable technologies. Global offshore wind capacity additions reached 19.6 GW, substantially exceeding the 11 GW installed in 2024 and surpassing the previous 2021 peak. Total operational offshore wind capacity worldwide grew to approximately 104 GW, representing a 14% year-over-year increase and generating sufficient electricity to power more than 90 million homes globally.

Sector-wide expenditure for offshore wind alone reached an estimated $80 billion in 2025, more than double the $31 billion invested in 2024, driven by a combination of large-scale project construction in China, accelerating European deployment, and emerging market development in Southeast Asia. Clean energy technologies overall attracted approximately $2.2 trillion in investment globally, with offshore renewables, hydrogen infrastructure, carbon capture, and grid modernization accounting for the majority of capital deployment.

The hydrogen economy experienced transformative growth, with over 1,570 clean hydrogen projects announced across 70+ countries, representing more than 500 GW of planned electrolyzer capacity valued at approximately $680 billion. Critically, the number of projects reaching final investment decision (FID) or entering operation increased substantially, with investment in hydrogen technologies rising 70% to nearly $8 billion in 2025. Carbon capture, utilization, and storage (CCUS) capacity expanded from 50 Mt CO_2 per year to approximately 75 Mt, with substantial projects becoming operational in Norway, Indonesia, and North America.



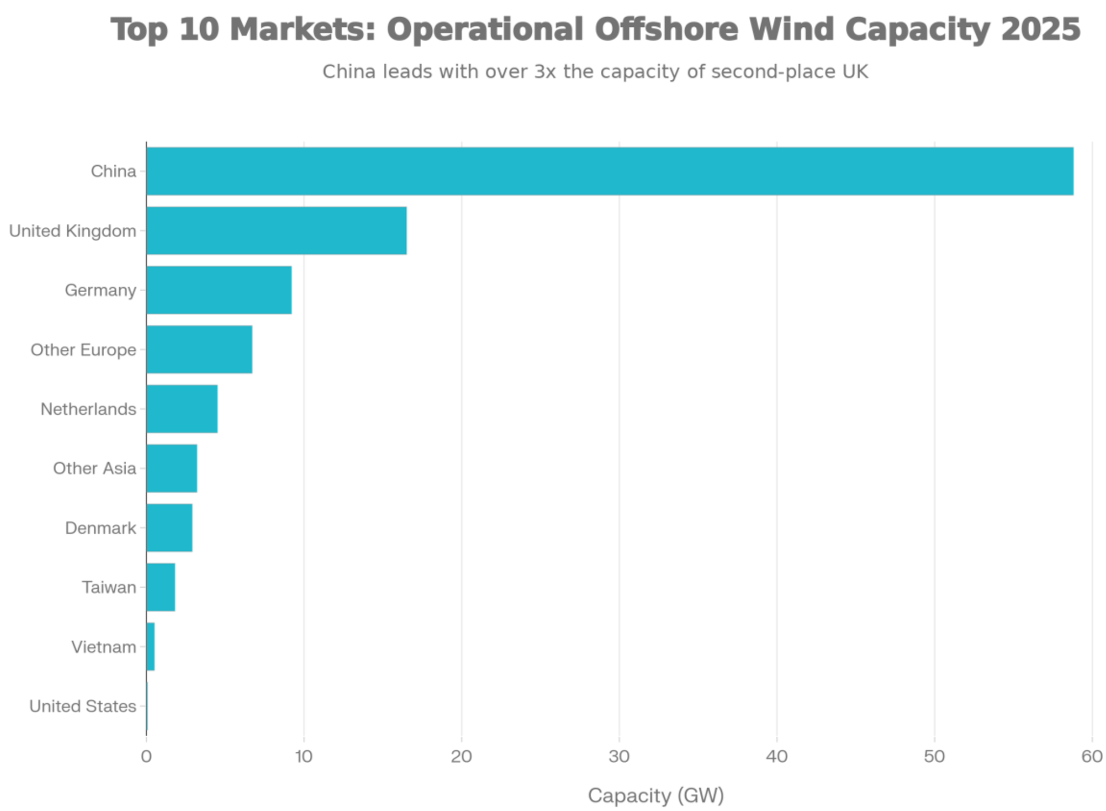
Year-over-year comparison of key offshore low carbon energy market indicators, demonstrating substantial growth in offshore wind deployment, investment levels, hydrogen project development, and carbon capture infrastructure in 2025.

Floating offshore wind emerged as a commercially viable technology, with 2.5 GW operational globally by year-end 2025, led by deployment in China (45%), the UK (41%), and France. The UK maintained its position as Europe's offshore wind leader with over 16 GW of operational capacity, while China consolidated its dominance with nearly 59 GW installed, representing approximately 56% of global capacity.

Offshore Wind: Record Deployment Amid Regional Divergence

Global Capacity Expansion and Market Leadership

The offshore wind sector experienced its strongest year of deployment since the industry's inception, adding 19.6 GW of new capacity globally in 2025—a 78% increase over 2024 installations. This surge was driven predominantly by China, which accounted for 65% of new capacity additions with approximately 12.7 GW commissioned during the year. China's aggressive deployment strategy, supported by provincial government mandates and streamlined permitting, propelled the nation's cumulative offshore wind capacity to 58.8 GW, cementing its position as the world's undisputed market leader.



Leading offshore wind markets by operational capacity in 2025, with China dominating at nearly 59 GW, followed by the UK and European markets, while the US lags significantly behind in deployment.

Europe added approximately 6.8 GW in the first half of 2025 alone, with Germany emerging as the region's growth engine through successful implementation of EU permitting reforms and 5 GW of planned annual installations. The UK commissioned multiple major projects including the completion of Neart na Gaoithe (450 MW) and progression of Berwick Bank (4.1 GW), which received Scottish Government consent in July 2025 as the world's largest consented offshore wind farm. Poland's BC-Wind project (390 MW) achieved financial close with €2 billion in backing, signaling the Baltic Sea's emergence as Europe's next major offshore wind theater.

The United States offshore wind sector, by contrast, faced severe headwinds throughout 2025 due to hostile policy shifts under the Trump administration. The Bureau of Ocean Energy Management (BOEM) rescinded all designated Wind Energy Areas on the Outer Continental Shelf in July 2025, effectively halting new lease sales and creating profound uncertainty for developers. Multiple major projects experienced delays or cancellations, including voluntary remands of New England Wind and SouthCoast Wind, while RWE withdrew from New York's 3 GW Community Offshore Wind project after investing $1.1 billion in lease areas. Despite these setbacks, projects with secured contracts and advanced permitting—including Empire Wind 1, Sunrise Wind, and Coastal Virginia—continued toward construction phases.

Asia-Pacific: The Emerging Growth Frontier

Southeast Asia established itself as the offshore wind industry's most dynamic emerging market in 2025, driven by accelerating regulatory frameworks and substantial foreign investment. The Philippines completed its first offshore wind auction in November 2025, awarding rights to develop 3.3 GW of capacity with clear grid connection plans and port strategies, marking the sector's transition "from potential to reality" according to Energy Secretary Sharon Garin. ACEN partnered with Copenhagen Infrastructure Partners to co-develop up to 1 GW in Camarines Sur province, while Chinese manufacturer Mingyang Smart Energy explored a 2 GW project in the northern Philippines.

Vietnam advanced crucial offshore wind regulations throughout 2025, with the National Assembly proposing minimum charter capital requirements of $379 million per developer and 15% equity commitments, alongside 90% power purchase agreement guarantees for projects connecting by 2031. The revised Power Development Plan 8 targets 6 GW of offshore wind by 2030 and 17-17.5 GW by 2035, supported by seabed-use fee waivers and priority grid access. Despite Equinor's earlier withdrawal due to regulatory delays, investor confidence rebuilt substantially, with Copenhagen Infrastructure Partners and PNE AG advancing multi-billion dollar projects.

Taiwan sustained its position as Asia's second-largest offshore wind market, achieving financial close on the 495 MW Fengmiao I project in March 2025 and signing long-term corporate power purchase agreements for the 495 MW Formosa 4 wind farm. The island's robust regulatory framework and established supply chain continued attracting international investment, positioning Taiwan as the benchmark for emerging Asian markets.

European Market Consolidation and Policy Support

Europe demonstrated remarkable policy consistency throughout 2025 despite economic headwinds, with the European Commission endorsing 100 hydrogen and renewable electricity Projects of Common Interest (PCIs) that will benefit from accelerated permitting and access to Connecting Europe Facility funding. The Commission's Grids Package, unveiled in December 2025, committed €240 billion ($282 billion) to hydrogen network development through 2040, representing unprecedented infrastructure investment.

The UK Government's commitment to offshore wind strengthened significantly, with the Department for Energy Security and Net Zero fast-tracking £300 million through Great British Energy to invest in domestic supply chains for floating platforms and cables. Scotland emerged as a floating wind powerhouse, with Salamander Offshore Wind Farm achieving Section 36 Consent in July 2025 as the first Innovation and Targeted Oil and Gas (INTOG) project to reach this stage, paving the way for commercial-scale floating deployment ahead of ScotWind projects. Port of Cromarty Firth secured £55 million in Floating Offshore Wind Manufacturing Investment Scheme (FLOWMIS) funding to establish the UK's first custom-built floating wind integration hub.

Germany's He Dreiht project (960 MW) achieved first power and is set to become the country's largest offshore wind farm by mid-2026, notably financed entirely without subsidies through power purchase agreements and institutional capital from Allianz and Norges Bank. This milestone validated the commercial viability of subsidy-free offshore wind at gigawatt scale in competitive European markets.

Green Hydrogen: From Aspiration to Industrial Deployment

Project Pipeline and Investment Surge

The global hydrogen economy transitioned decisively from demonstration to commercial deployment in 2025, with investment rising 70% to nearly $8 billion as developers pushed forward projects that had reached final investment decision. Over 1,570 clean hydrogen projects were announced across more than 70 countries, representing over 500 GW of planned electrolyzer capacity valued at approximately $680 billion—though only 75 billion had reached FID by year-end.

The number of projects in construction or operation increased substantially, with flagship facilities in Saudi Arabia, China, Europe, and the United States leading industrial-scale production. Saudi Arabia's NEOM Green Hydrogen Project—backed by Air Products, ACWA Power, and the Saudi state—progressed toward its 2026-2027 commissioning target, utilizing 4 GW of renewable energy to power 2.2 GW of electrolyzers producing approximately 600 tonnes of hydrogen daily. This $8.4 billion facility will become the world's largest green hydrogen plant upon completion.

China commissioned the world's largest operational green hydrogen facility, Sinopec's Kuqa Plant in Xinjiang, utilizing 260 MW of electrolyzers powered by renewable electricity for refinery applications. Despite early technical challenges, the project anchors China's broader plan to exceed 100 GW of electrolyzer capacity by 2030, positioning the nation to dominate global hydrogen production. In Europe, the Netherlands progressed Shell's Holland Hydrogen I project, while multiple Spanish facilities advanced with €126.4 million in national co-funding for 160 MW combined electrolyser capacity.

Policy Frameworks and Market Mechanisms

European policy leadership in hydrogen infrastructure reached new heights in 2025. The EU's third Hydrogen Bank auction, launched in December 2025, mobilized over €3 billion in total funding—€1.3 billion from EU budget support plus €1.3 billion from Germany and €415 million from Spain—to de-risk commercial-scale production projects. This marked a qualitative shift toward treating renewable hydrogen as strategic infrastructure eligible for substantial public co-investment.

The EU's Delegated Act on low-carbon hydrogen, which entered force in December 2025, provided critical regulatory clarity for both CCS-enabled blue hydrogen and grid- or nuclear-powered electrolysis, extending low-carbon classification to ammonia, methanol, and synthetic fuels. The Commission's Hydrogen Mechanism, launched as part of the European Hydrogen Bank, created a matchmaking platform connecting renewable hydrogen producers with credible EU-based offtakers, addressing the sector's most persistent barrier—securing long-term purchase agreements.

Analysis from Westwood Energy revealed that only 25% of announced European hydrogen projects had confirmed offtake agreements or memoranda of understanding, with 72% targeting electrolytic hydrogen production. Geographically, 47% involved co-located supply and demand, while 40% concentrated in industrial hubs and ports with shared infrastructure. End-use sectors showed chemicals (35%), steel (19%), and refining (15%) dominating commitments, confirming early adoption occurs primarily in existing hard-to-abate industrial applications.

The Hydrogen Council's Global CEO Summit in Seoul (December 2025) signaled the industry's shift from venture-stage innovation to mature commercial deployment, with leaders endorsing the "Hydrogen 2030: Lead. Build. Deliver" communiqué committing to concrete commercial delivery targets. Total announced clean hydrogen investments were projected to reach $680 billion by 2030, with the US hydrogen market alone forecast to reach $56.8 billion by 2033.

Regional Hydrogen Strategies

Asia-Pacific nations accelerated green hydrogen development as energy security imperatives intensified. India launched the Green Hydrogen Certification Scheme in May 2025, providing a transparent framework for domestic production and export. Malaysia advanced green hydrogen initiatives supporting Southeast Asia's energy transition, while South Korea announced coal plant closures by 2040 and hydrogen infrastructure investments as part of its Powering Past Coal Alliance commitment. Japan maintained its hydrogen roadmap focusing on domestic production and international supply partnerships, while Australia positioned itself as a major hydrogen exporter despite project cancellations including Trafigura's Port Pirie facility.

The United States, despite federal policy uncertainty, maintained momentum through state-level initiatives and Inflation Reduction Act incentives. At least 76 green hydrogen projects backed by $36 billion in investment were planned across Texas, Louisiana, Alabama, and California, with several major facilities targeting 2025-2026 commissioning. Blue hydrogen dominated US market projections, with over 1.5 million tonnes per annum of capacity expected to reach FID in 2025—a tenfold increase over green hydrogen—positioning the US as the world's leading blue hydrogen producer.

Carbon Capture, Utilization and Storage: Scaling Toward Gigatonne Targets

Capacity Expansion and Commercial Momentum

Global CCUS capacity expanded from approximately 50 Mt CO_2 per year at the start of 2025 to 75 Mt by year-end, with eight new projects entering operation during the year, though most were relatively small-scale (5,000-400,000 tonnes annually). The International Energy Agency projected operational capacity could reach 430 Mt CO_2 per year by 2030 based on the current project pipeline, though this remains well below the 1 Gt required under the Net Zero Emissions by 2050 scenario.

The sector demonstrated important commercial progress, with flagship facilities advancing in Norway, Indonesia, North America, and Europe. Norway's 400,000 tonne per year facility became operational in 2025, while Indonesia's major liquefied natural gas plant implemented CCUS infrastructure. The UK Government's 2025 Spending Review allocated £9.4 billion for CCUS clusters including development funding for Scotland's Acorn Project and Humberside's Viking CCS, signaling regulatory conviction that projects will reach FID and move to construction in 2026-2028.

Over 700 CCUS projects at various development stages globally represented 435 Mt of capture capacity and 615 Mt of storage capacity per year by decade's end. North America and Europe accounted for 80% of capture capacity either operational or under construction, with China and the Middle East representing a quarter of projects in these advanced stages. The concentration highlighted regional disparities in deployment and the critical need for technology transfer to emerging markets.

Direct Air Capture and Next-Generation Technologies

Direct air capture (DAC) technology approached a critical commercialization milestone with Occidental Petroleum's 1PointFive Texas Stratos facility—the world's largest DAC plant at $1.3 billion with 0.5 Mt per year nameplate capacity—set to begin operations by year-end 2025. The facility must contract more than 43% of its carbon removal credits to remain profitable, highlighting the challenge of securing high-priced offtake agreements that has emerged as the most effective commercial strategy for DAC projects.

Research firm Wood Mackenzie projected CCUS capacity could triple by 2030 and surpass 2,000 Mt per year by 2050, though 2025 proved challenging with only 10% of the 270 Mt targeting FID actually achieving that milestone by August. The sector faced headwinds including project cancellations, delays, and persistent cost challenges, with the levelized cost of capture needing to fall below $100 per tonne to achieve widespread commercial viability.

Policy Development and Hub Formation

European policy frameworks matured substantially in 2025. Belgium's Flanders and Wallonia regions signed a joint declaration with 17 companies to advance the CO_2 value chain, with both governments approving regulatory frameworks for CO_2 transport and concluding bilateral agreements with Denmark, the Netherlands, and Norway enabling cross-border CO_2 transport for permanent storage. Greece's Kamari plant targeted production of 3 million tonnes of zero-carbon cement with €234 million in EU funding, though concerns mounted regarding third-country cement imports not subject to carbon pricing.

The 5th Industrial Carbon Management Forum in Athens (December 2025) marked a decisive shift from policy design toward delivery, financing, and large-scale implementation, with discussions focusing on establishing competitive CCUS markets anchored in Track-1 clusters and expandable through future licensing rounds. The Asian Development Bank's November 2025 policy amendments explicitly enabled CCUS projects using depleted oil and gas fields for CO_2 storage across ASEAN member states, removing a major financing barrier for regional operators evaluating infrastructure repurposing.

The World Economic Forum's September 2025 report "Defossilizing Industry: Considerations for Scaling-up Carbon Capture and Utilization Pathways" emphasized that carbon pricing, mandates, and tax credits are vital to overcome cost barriers, while stronger evidence of CCU's effectiveness is essential for building confidence and scaling the technology. The report identified carbon pricing, mandates, and tax credits as critical policy levers, alongside the need for robust evidence demonstrating CCU's climate effectiveness.

Floating Offshore Wind: Commercial Breakthrough and Supply Chain Development

Technology Maturation and Project Pipeline

Floating offshore wind achieved a defining commercial breakthrough in 2025, with global operational capacity reaching 2.5 GW—a ninefold increase from the 277 MW operating at year-start. France led deployment with 85 MW added through EDF's PGL project and additional installations bringing the nation's total to over 100 MW, leapfrogging China and the UK to become the second-largest floating market by operational capacity. China installed its first 16 MW floating demonstration turbine—the largest completed floating unit globally—as the first of four 16-18 MW demonstration turbines expected over 12-18 months ahead of commercial-scale projects.

The global floating wind pipeline expanded to 221 GW across 16 operational projects in seven countries, with 93 MW undergoing offshore construction, 9.4 GW consented or in pre-construction, 20.8 GW with planning applications submitted, 59.7 GW with site exclusivity, and 130.7 GW in early development. RenewableUK's November 2025 forecast projected nearly 2.5 GW could be operational globally by end-2030, with China (45%) and the UK (41%) accounting for the vast majority, while activity in France, Norway, and Japan accelerates into the 2030s.

Scotland consolidated its position as the global floating wind epicenter through a series of major project consents and supply chain investments. Salamander Offshore Wind Farm achieved Section 36 Consent in July 2025 as the first INTOG innovation project to reach this stage, unlocking Scotland's deepwater wind resources and de-risking future ScotWind developments. Cerulean Winds lodged the Environmental Impact Assessment for its 1 GW Aspen floating project, while Buchan Offshore Wind submitted onshore consent applications for its ScotWind development targeting foundation manufacturing at Ardersier Energy Transition Facility.

Infrastructure Investment and Manufacturing Capacity

Port infrastructure investments reached unprecedented levels to support floating wind industrialization. Port of Cromarty Firth secured £55 million in FLOWMIS funding for its Phase 5 expansion, establishing the UK's first custom-built floating wind integration hub with up to 800m of quayside capacity and 170-320 construction jobs, expanding to 280-1,000 operational positions. Highlands and Islands Enterprise committed £24.3 million at Kishorn Port for dry dock expansion and land reclamation to manufacture floating foundations, with the enhanced facilities forecast to support up to 1,500 jobs.

The Crown Estate awarded Ocean Winds development rights for a third Celtic Sea floating site (358 km^2 in 71-88m water depths) capable of 1.5 GW phased development, reinforcing the company's leadership in floating technology following delivery of Portugal's WindFloat Atlantic (2020) and France's EFGL demonstrator. Norway approved two floating wind consortia—Equinor-Vårgrønn and Deep Wind Offshore Norway-EDF Renewables—for the 1.5 GW Utsira Nord project with up to NOK 35 billion ($3.5 billion) in state subsidies, marking a critical step toward commercial-scale floating deployment.

Flotation Energy's Green Volt project progressed as Europe's first commercial-scale floating offshore wind farm (560 MW), receiving both onshore and offshore consent in April 2024 and securing a Contract for Difference in September 2024, remaining on track for 2029 commissioning to supply electricity to North

Sea oil and gas platforms while exporting surplus power to the UK grid. The project is expected to mitigate emissions equivalent to approximately 1 million tonnes of CO_2 annually.

Cost Reduction and Market Dynamics

The levelized cost of electricity (LCOE) for floating wind remained elevated relative to fixed-bottom offshore wind, with cost reductions delayed from pre-2030 targets to the mid-2030s due to intensive manufacturing requirements, low deployment levels restricting economies of scale, and competition among multiple floating substructure technologies preventing standardization. Despite these challenges, floating wind technology enables deployment in deeper waters where wind speeds are stronger and more consistent, unlocking vast resources in the Atlantic, Mediterranean, and northern European seas where water depths exceed 60 meters.

Wood Mackenzie forecast that fixed-bottom offshore wind LCOE will decline 67% by 2060, while broader industry analysis projected continued cost reductions through technological improvements, supply chain optimization, and economies of scale reinforcing offshore wind's position as the dominant power generation technology globally. Solar PV with single-axis tracking achieved regional LCOEs as low as $37 per MWh in the Middle East and Africa, while onshore wind projects in China, India, and Vietnam demonstrated global competitiveness at $25-70 per MWh.

Marine Energy: Tidal and Wave Technology Advances

Technology Demonstration and Grid Integration

Marine energy achieved a landmark technical milestone in December 2025 when the European Marine Energy Centre (EMEC) successfully demonstrated the world's first integration of tidal power, battery storage, and hydrogen production at its Eday onshore facility in Scotland. The demonstration combined Orbital Marine Power's O2 2 MW tidal turbine, Invinity Energy Systems' vanadium flow batteries, and ITM Power's 670 kW electrolyzer, validating multiple operational scenarios including direct turbine-to-electrolyzer supply, battery charging during high tidal generation, and continuous electrolyzer operation through battery discharge during low tidal periods.

Andrew Scott, CEO of Orbital Marine Power, emphasized that tidal energy's predictable power generation combined with battery storage integration "maximizes generation and minimizes curtailment while creating new markets for tidal energy and opportunities for industrial offtakers to decarbonize". The demonstration, conducted under the Interreg North-West Europe funded ITEG project, validated technical pathways for combining marine energy with hydrogen production in coastal areas facing grid constraints, with potential applications in Scotland, Wales, Canada's Bay of Fundy, and Southeast Asian locations.

The UK Government launched the Marine Energy Taskforce in June 2025 with backing from The Crown Estate and Crown Estate Scotland, tasked with developing a roadmap to unlock the country's 25 GW of accessible wave energy and 11 GW of tidal stream capacity. Led by Energy Minister Michael Shanks MP, the Taskforce brings together government, industry, and academia stakeholders focusing on site development, financing mechanisms, innovation acceleration, and supply chain strengthening over a 12-month period. A University of Edinburgh study projected scaling the sector could add £50 billion to the UK economy and create over 90,000 jobs, with combined wave and tidal stream potential exceeding these figures substantially.

Commercial Project Advancement

CorPower Ocean was appointed to lead a £30 million ($35 million) European project in December 2025 aimed at improving wave energy commercialization, supporting UK Government ambitions for wave and tidal stream development as part of the nation's clean energy strategy. Research indicated wave energy under a high-growth scenario supported by a modernized UK supply chain could deliver over £30 billion ($40 billion) in gross value added and support tens of thousands of jobs, with the combined wave and tidal sector economic impact potentially exceeding £50 billion ($66.6 billion).

Operational ocean energy capacity in the EU reached 2.82 MW by end-2024, including 1.63 MW tidal energy, 1.12 MW wave energy, and approximately 70 kW salinity gradient, with Europe accounting for approximately half of the global 508 MW total capacity. France's La Rance tidal barrage (240 MW), operational since 1966, underwent renovation works with electricity production expected to restore to 520 GWh annually, equivalent to consumption in Rennes' 200,000+ population.

The LCOE for ocean energy improved substantially, with tidal energy reference prices in the UK decreasing 33% from 303 €/MWh in 2023 to 204 €/MWh in 2024, signaling significant cost reduction progress. Several tidal projects awarded contracts in 2023-2024 demonstrated commercial viability, though LCOEs ranged from 110-480 €/MWh for tidal and 160-750 €/MWh for wave energy, highlighting the need for continued cost reduction. Horizon 2020 funded 70 ocean energy projects totaling €183 million between 2014-2022, with Horizon Europe adding €51 million for 15 projects since 2021.

Investment Trends and Financial Flows

Record Capital Deployment

Global investment in renewable energy reached unprecedented levels in 2025, with clean energy technologies attracting approximately $2.2 trillion across renewables, nuclear, grids, storage, low-emissions fuels, efficiency, and electrification. Total energy investment rose to $3.3 trillion, with clean energy commanding twice the capital of fossil fuels ($1.1 trillion), marking a decisive structural shift in global energy finance.

Offshore wind investment surged most dramatically, reaching $80 billion in 2025 compared to $31 billion in 2024, driven by large-scale project construction and elevated project costs outside mainland China. Asset finance for offshore wind exceeded 2024's total of $31 billion within the first half of 2025 alone, with $39 billion committed through June. The sector benefited from sizable project schedules aligned with government auction calendars, creating natural investment volatility but demonstrating robust long-term capital flows.

Solar energy maintained its position as the largest single investment category, with combined utility-scale and rooftop solar projected to reach $450 billion in 2025, outpacing oil production investment. Nuclear investment continued its resurgence, growing 50% over five years to exceed $70 billion, with growing interest in small modular reactors. Grid and storage investment reached $410 billion, driven by electrification demands and the need to integrate variable renewables.

Regional Investment Patterns

North America demonstrated resilience despite federal policy uncertainty, with offshore wind market size valued at $21.4 billion in 2025 and projected to grow at 11.3% CAGR through 2033. The US market alone reached $16.9 billion (11.1% CAGR), while Canada contributed $2.6 billion (12.1% CAGR). State-level initiatives in Texas, Louisiana, California, and the Northeast maintained momentum through corporate power purchase agreements and local policy support.

Asia-Pacific emerged as the fastest-growing region with the highest CAGR, driven by China, Japan, and India leveraging extensive coastlines and abundant wind resources. China's aggressive carbon neutrality targets and massive offshore wind investments, combined with South Korea and Japan's floating wind technology development and India's National Offshore Wind Energy Policy, positioned the region for sustained growth. Southeast Asian markets including Vietnam, the Philippines, and Indonesia attracted substantial foreign investment as regulatory frameworks matured.

Europe demonstrated stable investment patterns supported by robust policy frameworks, with the UK offshore wind market valued at €2.8 billion in 2025 (12.6% CAGR). Germany, Netherlands, Denmark, and Poland maintained strong investment flows through established support schemes and streamlined permitting, while the EU's Connecting Europe Facility and Hydrogen Bank auctions mobilized billions in infrastructure capital.

Financing Mechanisms and Risk Factors

Contract for Difference (CfD) mechanisms proved critical for de-risking offshore wind investments, with the UK's AR7 auction framework including Clean Industry Bonus provisions incentivizing domestic supply chain commitments. Power purchase agreements (PPAs) emerged as essential financing tools, particularly for subsidy-free projects like Germany's He Dreiht, with corporate PPAs doubling globally as major technology companies and manufacturers pursued science-based emissions targets.

Investment trends revealed a reassessment of risk profiles, with asset finance for utility-scale solar and onshore wind declining 13% in 1H 2025 to the lowest share of total investment since 2006, as developers allocated capital where project returns appeared strongest. Small-scale distributed solar and offshore wind attracted disproportionate investment growth, reflecting shifting developer preferences and policy incentive structures.

The IEA's World Energy Investment 2025 report highlighted that electricity investments significantly exceeded all fossil fuel investments combined, with capital moving decisively to the electricity sector due to growing consumption and generation needs. However, upstream oil investments experienced their biggest drop since 2016 excluding the COVID pandemic, demonstrating accelerating capital reallocation toward clean technologies.

Supply Chain Dynamics and Industrial Strategy

Manufacturing Capacity and Bottlenecks

Global offshore wind supply chains faced acute pressures in 2025 despite massive capacity expansion efforts. Turbine manufacturing capacity grew substantially, with Nordex producing 2,541 MW in Q3 2025 (23% increase year-over-year) and installing 420 turbines totaling 2,576 MW across 20 countries. Order intake surged 25.7% to 2,170 MW in Q3, with total order backlog reaching €14.9 billion including €9.3 billion in projects and €5.6 billion in service segments.

Despite capacity increases, supply chain constraints persisted particularly for specialized components. Global competition for cable manufacturing created bottlenecks, with European offshore wind projects competing with North American and Asian demand for limited production capacity. Installation vessel availability remained critical, with Asian shipyards—particularly Hanwha, Samsung Heavy Industries—emerging as primary sources of heavy-lift vessel capacity for European contractors. Cadeler's delivery of the Wind Mover wind turbine installation vessel from Hanwha Ocean approximately one month ahead of schedule highlighted both Asian manufacturing dominance and the critical importance of timely vessel availability.

Turbine technology evolved rapidly toward larger capacity ratings, with 15-16 MW units becoming standard and multiple manufacturers advancing 18+ MW designs. Vestas commissioned its first 15 MW offshore turbine at Germany's He Dreiht in November 2025, while China installed the world's largest 16 MW floating demonstration unit. These increases—representing six times the energy output of 2.3 MW turbines installed at Vattenfall's Baltic 1 in 2010—necessitated scaled-up logistics, heavier lifting capacity, revised installation methodologies, and upgraded electrical infrastructure.

Regional Content Requirements and Localization

Local content requirements intensified globally as governments sought to capture economic benefits from offshore wind development. The UK embedded Supply Chain Plan Requirements into CfD application processes, with bidders required to submit detailed strategies demonstrating domestic industry support, independently assessed as critical factors in award decisions. The UK Government brought forward £300 million for Great British Energy to invest in offshore wind supply chains including floating platforms and cables, explicitly aiming to ensure the clean energy future is "built in Britain".

European supply chain investments accelerated substantially. The Crown Estate granted £13 million to 16 offshore wind supply chain projects through its Supply Chain Accelerator fund, including low-carbon reef scour protection, automated mooring systems, and floating infrastructure. Scotland's Strategic Investment Model supported 37 port and supply chain projects, with 29 identified as high or medium relevance receiving collaborative support and securing approximately £60 million in public sector investment leveraging additional private funding. Key projects included Kishorn Port, XLCC's Hunterston HVDC cable factory, Subsea Micropiles, Port of Nigg's Inner East Quay, and Scapa Deep Water Quay.

Taiwan maintained robust local content frameworks through its established regulatory regime, while Vietnam's proposed offshore wind regulations emphasized Vietnamese equipment and services partnerships to ensure domestic economic benefits. The Philippines' auction framework incorporated local content considerations, though the balance between attracting international capital and ensuring domestic value capture remained delicate across emerging markets.

Decommissioning and Circular Economy

The offshore decommissioning market reached critical scale in 2025, with UK Continental Shelf (UKCS) annual spending exceeding £2 billion for the first time in 2024 and forecasts projecting average expenditure of nearly £3 billion per year throughout the decade. Wells remained the largest decommissioning activity area, while subsea removals, heavy-lift operations, and onshore dismantling accelerated rapidly.

A significant challenge emerged around decommissioning backlogs and financial assurances. The North Sea Transition Authority named 13 operators falling behind on well abandonment schedules, with 153 wells in arrears and projections indicating decommissioning spending could overtake new oil and gas capital investment by 2028. The US Gulf of Mexico faced over 2,500 wells and 500 platforms overdue for decommissioning, with estimated costs reaching $30 billion and delays increasing environmental risks and taxpayer burdens.

Innovative approaches emerged around infrastructure repurposing for carbon storage and hydrogen production. The Asian Development Bank's November 2025 policy amendments explicitly endorsed converting decommissioned oil and gas infrastructure into CO_2 storage facilities, creating pathways for platform-to-storage conversion in mature fields across Indonesia, Malaysia, Brunei, Thailand, and Vietnam. This represented a paradigm shift from liability-focused full removal toward asset life extension and multi-use optimization.

Offshore wind farms themselves began confronting end-of-life considerations, with a report by Seas at Risk in December 2025 warning that thousands of turbines will require dismantling, upgrading, or repowering between 2025-2050. The degraded state of Europe's marine ecosystems and delays in achieving biodiversity targets elevated urgency around responsible decommissioning planning, creating opportunities for turbine dismantling, foundation removal or repurposing, and marine environmental restoration services.

Workforce Development and Skills Transition

Employment Growth and Skills Gaps

The offshore renewable energy sector demonstrated substantial job creation potential throughout 2025, with employment projections indicating dramatic workforce expansion requirements. Scotland's offshore wind industry supported 10,000 full-time equivalent jobs in 2021, with figures expected to increase markedly as Moray East, Seagreen, Neart na Gaoithe, and Moray West projects reached operational phases. With over 40 GW of offshore wind in Scotland's construction pipeline, the sector promised the biggest jobs bonanza since the peak of North Sea oil and gas.

UK-wide projections from the Climate Change Committee estimated 135,000 to 725,000 new jobs could be created by 2030 in low-carbon sectors, though reports highlighted "inadequate" green skills provision creating critical deficits threatening net-zero target achievement. The offshore wind sector specifically projected over 100,000 jobs by 2030 with appropriate policy support, requiring substantial upskilling and training investment to meet demand.

Skills gaps manifested most acutely in specialized technical roles. High demand emerged for wind turbine engineers, electrical engineers specializing in grid integration, BESS specialists with battery chemistry and power electronics expertise, project managers proficient in agile methodologies, and data analysts capable of energy system modeling. The shift toward 7 MW onshore turbines and 15-18 MW offshore units demanded deeper specialization in structural integrity, power electronics, and installation methodologies.

Training Infrastructure and Transition Programs

Scotland developed comprehensive skills support infrastructure for offshore wind sector transitions. The Energy Skills Passport enabled workers and employers to identify qualifications and training standards needed for specific roles, mapping mutually recognized credentials across sectors to avoid training duplication while charting career pathways. Global Wind Organisation (GWO) training facilities expanded throughout Scotland, delivering approved safety courses mandatory for wind turbine work.

The Oil and Gas Transition Training Fund, backed by £900,000 UK Government funding, provided current or former oil and gas workers in Aberdeen City and Aberdeenshire access to industry-recognized training for opportunities in offshore wind and related sectors. Universities and colleges offered industry-aligned courses, apprenticeships, and graduate programmes in renewable energy and offshore engineering, while organizations like OPITO led cross-industry skills alliances developing an all-energy workforce.

SOWEC's February 2025 Skills Guide, created in partnership with Skills Development Scotland, highlighted thousands of jobs the offshore wind sector will support alongside routes to entry and critical skills gaps. The guide profiled 85 different key job roles requiring diverse skills and offering varied career progression opportunities, from entry-level technicians through senior project management and specialized engineering positions.

International frameworks recognized substantial skill transferability between oil and gas and renewable sectors. Approximately two-thirds of workers in oil and gas possessed core skills transferable to other energy industries, with offshore wind, geothermal energy, and carbon capture showing particularly strong overlap including project engineers, welders, and drilling technicians. Offshore engineering and floating infrastructure skills from oil and gas platforms translated directly to floating offshore wind, green hydrogen, CCS, and subsea cable deployment applications.

Education and Industry Partnerships

Educational institutions played critical roles in workforce development. The Green Jobs Workforce Academy, delivered by Skills Development Scotland, helped individuals take greener approaches to careers through accessing training, learning new skills, and finding employment opportunities. The National Energy Skills Accelerator (NESA) provided a single point of contact for the energy industry to access training, skills development programmes, and R&D capabilities supporting changing workforce needs during energy transition.

Industry certifications through organizations like the Offshore Petroleum Industry Training Organisation (OPITO) and Global Wind Organisation (GWO) established standardized safety and technical competency frameworks facilitating worker mobility across projects and geographies. The Offshore Wind Growth Partnership supported UK offshore wind supply chain development, generation of know-how, skilled jobs, and export income for businesses.

High-voltage skills commanded particular demand with massive investment in battery storage, electrified transport, and transmission infrastructure, creating opportunities for commissioning specialists, protection system engineers, and project engineers across wind, solar, utility-scale storage, and EV charging networks. Safety procedures for high-voltage environments proved largely universal, facilitating worker transitions. HSE leadership and regulatory compliance expertise transferred exceptionally well across sectors, particularly for professionals with experience in audits, incident response, and cross-border compliance.

Policy and Regulatory Landscape

European Union Framework Strengthening

The European Union consolidated its position as the global leader in offshore low carbon energy policy during 2025, implementing comprehensive reforms accelerating project deployment while strengthening market integration. The Renewable Energy Directive III (RED III), adopted in March 2024 and fully operationalized in 2025, established "go-to areas" pre-assessed for environmental conflicts and biodiversity, capping permitting timelines at 12 months for new builds and providing developers planning certainty.

The revised Trans-European Networks for Energy (TEN-E) Regulations, operationalized in 2025, supported offshore energy "meshes"—interconnected transmission hubs across the North Sea and Baltic—allowing multiple wind farms from different nations to connect to shared grids, improving reliability and lowering infrastructure costs. The European Commission's December 2025 Grids Package committed €240 billion to hydrogen network development through 2040, simultaneously endorsing 100 hydrogen and renewable electricity Projects of Common Interest benefiting from accelerated permitting and Connecting Europe Facility funding access.

Strategic Environmental Assessments (SEAs) became mandatory across most EU member states, evaluating cumulative impacts of multiple developments rather than project-by-project assessments, fundamentally guiding long-term spatial planning. The UK followed similar approaches through Habitats Regulations Assessment (HRA) reforms streamlining processes for "low risk" projects with robust ecological data, while the Offshore Wind Environmental Improvement Package launched in late 2023 enabled data sharing, coordinated environmental assessments, and earlier regulator engagement cutting average permitting time by 40%.

United Kingdom: Clean Power Commitment and Industrial Strategy

The UK Government maintained unwavering commitment to clean power by 2030 despite economic headwinds, with multiple policy initiatives reinforcing offshore wind's central role in energy security and decarbonization. The 2025 Spending Review confirmed £63 billion in clean energy investment over the parliamentary term, including £5.8 billion from the National Wealth Fund for ports, hydrogen, CCUS, gigafactories, and green steel, plus £500 million for hydrogen infrastructure targeting first regional networks operational by 2031.

Energy bill relief measures promised households £150/year reductions from April 2026 via ending the Energy Company Obligation (ECO) and Great British Insulation Scheme (£62/year saving) and government funding of 75% of Renewables Obligation legacy costs for three years (£92/year saving). The Department for Energy Security and Net Zero announced the Contract for Difference AR7 auction timeline, with the Clean Industry Bonus framework enabling generators to nominate the Offshore Wind Growth Partnership to deliver portions of minimum domestic content commitments, mobilizing supply chain investment.

Scotland demonstrated particular policy ambition, with the draft updated Sectoral Marine Plan for Offshore Wind Energy targeting delivery of 50 GW by 2030 including 5 GW of floating technology, alongside ScotWind projects representing 28 GW of potential generating capacity from the late 2020s onward. The Scottish Government's commitment of up to £500 million over five years to develop ports and offshore wind supply chain infrastructure, combined with doubling governmental consenting resources, enabled Salamander's 15-month consent timeline demonstrating accelerated approvals.

National Policy Statement revisions in 2025 incorporated offshore wind environmental improvements, wake effect considerations, and offshore transmission infrastructure guidance, while maintaining commitments to reduce consenting timelines, introduce strategic environmental compensation measures, and review Habitats Regulations Assessment procedures. The government's Industrial Strategy positioned offshore wind manufacturing as central to economic growth, with Great British Energy tasked with investing in domestic supply chains to ensure resilient component production for clean power delivery.

Asia-Pacific Regulatory Evolution

Southeast Asian regulatory frameworks matured substantially, transitioning from aspirational targets to actionable implementation mechanisms. Vietnam's National Assembly advanced offshore wind legislation throughout 2025, with proposed charter capital requirements ($379 million minimum per developer), equity commitments (15% of total investment), PPA guarantees (90% of output during loan repayment), priority grid connection for projects connecting by 2031, and seabed-use fee waivers to lower developer costs. Power Development Plan 8's targets of 6 GW by 2030 and 17 GW by 2035 received government backing with regulatory acceleration.

The Philippines completed its first offshore wind auction in November 2025, awarding 3.3 GW across designated seabeds with clear grid connection plans, port strategies, and equipment logistics, representing a transition "from potential to reality" according to Energy Secretary Garin. The auction's transparency and structured approach attracted major international developers including ACEN-Copenhagen Infrastructure Partners partnerships demonstrating investor confidence in the framework.

Taiwan maintained its position as Asia's regulatory benchmark through established offshore wind frameworks supporting 5.5 GW by 2025 and additional 10 GW by 2035, with corporate PPA mechanisms providing revenue certainty for projects like Formosa 4. The EU-Taiwan Trade and Investment Dialogue in December 2025 confirmed both parties' commitment to effectively implementing their 2024 understanding on offshore wind investments, addressing supply chain cooperation, technology transfer, and investment protection.

South Korea's coal phase-out commitment by 2040 and joining the Powering Past Coal Alliance positioned the nation as only the second major Asian economy after Japan to formalize such pledges, with offshore wind and hydrogen infrastructure featuring prominently in replacement capacity planning. Japan advanced floating wind technology development and maintained hydrogen roadmap implementation focusing on domestic production and international partnerships.

United States: Policy Reversal and State Resilience

The Trump administration's hostile stance toward offshore wind created profound market disruption throughout 2025. BOEM rescinded all designated Wind Energy Areas on the Outer Continental Shelf in July 2025, following the January 2025 Presidential Memorandum imposing a temporary withdrawal of all OCS areas from offshore wind leasing and comprehensive review of federal leasing and permitting practices. Secretary of the Interior Doug Burgum launched a full review of offshore wind regulations to "ensure alignment with the Outer Continental Shelf Lands Act and America's energy priorities," including the Renewable Energy Modernization Rule, financial assurance requirements, and decommissioning cost estimates.

The administration issued stop-construction orders for fully permitted projects including Empire Wind in New York, while revoking Clean Air Permits for projects like Atlantic Shores in New Jersey. Multiple voluntary remands of Construction and Operations Plans followed, including New England Wind and SouthCoast Wind offshore Massachusetts, effectively pausing projects as the federal government reconsidered positions. The policy shifts created existential challenges for developers, with major companies including RWE withdrawing from multi-billion dollar commitments.

State-level resilience partially offset federal hostility, with California's Energy Commission adopting a comprehensive strategic plan guiding 25 GW of floating offshore wind deployment by 2045, New York maintaining 9 GW offshore wind target commitments, and northeastern states coordinating procurement strategies through regional organizations. Corporate power purchase agreements emerged as critical mechanisms maintaining project viability amid federal uncertainty, with major technology companies and manufacturers pursuing direct renewable energy procurement independent of federal support.

Technology Innovation and Research Development

Advanced Turbine Technologies

Offshore wind turbine technology achieved remarkable scaling in 2025, with 15-18 MW units becoming standard for new projects and manufacturers developing 20+ MW prototypes. Vestas commissioned its first 15 MW offshore turbine at Germany's He Dreiht in November 2025, representing six times the energy output of 2.3 MW turbines installed 15 years earlier and demonstrating rapid technological advancement. China installed the world's first 16 MW floating demonstration turbine, the largest completed floating unit globally, as the initial deployment in a series of 16-18 MW demonstrations planned for 2025-2026 ahead of commercial-scale projects.

GE Vernova secured major European contracts including 42 turbines of the 6.1 MW-158m type for Romania's Ialomița wind farm (252 MW total capacity), demonstrating the continued relevance of "workhorse" turbine platforms in markets prioritizing proven technology over cutting-edge capacity. The company's global installed base of approximately 57,000 onshore turbines totaling nearly 120 GW positioned it among leading manufacturers, though offshore market share increasingly concentrated among Chinese, European, and select international suppliers.

Floating foundation technologies diversified substantially, with multiple competing designs advancing toward commercialization. BW Ideol's patented Damping Pool® floating substructure secured selection as the preferred foundation for Scotland's Buchan Offshore Wind project, with manufacturing planned at Ardersier Energy Transition Facility. Semi-submersible, spar-buoy, and tension-leg platform designs progressed through demonstration phases, with cost reduction dependent on standardization emerging as the critical determinant of commercial viability.

Digital Technologies and AI Integration

Digitalization transformed offshore wind operations through predictive maintenance, remote monitoring, and performance optimization systems. Data analytics capabilities using Python, R, Tableau, and Power BI became essential for energy forecasting and output maximization, directly addressing growing gaps between supply and demand for clean energy. SCADA systems, IoT sensors, and predictive maintenance tools enabled proactive asset management, reducing downtime and extending turbine lifespans.

Grid integration advanced through smart grid technologies enabling bi-directional power flows, energy management systems balancing variable renewable generation with demand, and sophisticated forecasting tools optimizing dispatch schedules. The UK's shift toward "first ready, first connected" grid policy elevated importance of efficient project execution and digital systems demonstrating readiness to progress, fundamentally altering competitive dynamics.

Artificial intelligence applications expanded across design optimization, performance monitoring, and maintenance scheduling, though precise quantification of AI's impact remained challenging. Complex design space navigation, performance trade-off balancing, and vast data analysis represented areas where AI promised substantial value, potentially accelerating innovation timelines and reducing costs.

Hydrogen Production and Storage Technologies

Electrolyzer technology achieved significant cost reductions and efficiency improvements throughout 2025. Alkaline electrolyzers remained the dominant commercial technology at industrial scale, with PEM (proton exchange membrane) electrolyzers gaining market share for applications requiring rapid response times and higher current densities. China began production at its first green hydrogen project utilizing both 5 MW alkaline electrolyzers and 2 MW PEM machines at Daye Green Power's $476 million facility in Hubei province, marking the first Chinese project storing hydrogen in underground caverns.

Costs for green hydrogen production were projected to decrease 60-80% by 2030, achieving cost parity with gray hydrogen in many regions as renewable electricity prices declined and electrolyzer manufacturing scaled. The gap between green hydrogen ($3.50/kg in 2020 trending toward $2.00/kg by

2030) and blue hydrogen ($1.80/kg in 2020 toward $1.50/kg by 2030) narrowed substantially, though blue hydrogen retained cost advantages in regions with low natural gas prices and existing pipeline infrastructure.

Hydrogen storage and transportation technologies advanced across multiple pathways. Underground cavern storage demonstrated viability in China's Daye project, while liquid organic hydrogen carriers (LOHC) and pipeline repurposing progressed as economically attractive transportation solutions. The EU's commitment to €240 billion in hydrogen network infrastructure through 2040 prioritized converted existing gas pipelines and new dedicated hydrogen pipelines, with the SouthH2 Corridor (Tunisia-Italy-Austria-Germany) and Southwest Hydrogen Corridor (Portugal-Spain-France-Germany) emerging as strategic priority routes.

Challenges and Barriers to Growth

Cost Pressures and Economic Viability

Despite substantial progress, offshore low carbon technologies faced persistent cost challenges threatening commercial viability and deployment timelines. Offshore wind project costs increased 30-40% over 2023-2024 due to inflation, supply chain bottlenecks, interest rate rises, and increased commodity prices, creating profitability pressures for developers operating under fixed-price contracts or aging CfD agreements. Several high-profile project cancellations and delays occurred as developers reassessed economics, including Trafigura's Port Pirie Hydrogen Project in Australia ($471 million) and multiple Victorian offshore wind projects totaling over 8 GW.

Green hydrogen production costs, while declining, remained above fossil alternatives in most markets, with the critical challenge of securing high-priced offtake agreements limiting commercial deployment. Only 25% of announced European hydrogen projects had confirmed offtake agreements, creating financing barriers and delaying FID for hundreds of projects. CCUS faced similar challenges, with capture costs needing to fall below $100 per tonne CO_2 to achieve widespread adoption, while DAC technologies required carbon credit prices exceeding $300/tonne to remain profitable.

Floating offshore wind LCOE remained elevated relative to fixed-bottom technology, with commercialization timelines pushing from pre-2030 targets to mid-2030s due to intensive manufacturing requirements, limited deployment restricting economies of scale, and competing technology designs preventing standardization. The cumulative effect of cost pressures forced developers to become more selective in project pursuits, with competitive intensity in auctions weakening as some bidders withdrew or reduced participation.

Supply Chain Constraints and Dependencies

Global supply chains demonstrated vulnerability to bottlenecks across critical components despite capacity expansion efforts. Cable manufacturing capacity proved particularly constrained, with European offshore wind projects competing against North American and Asian demand for limited production slots from specialized manufacturers. Installation vessel availability remained critical, with long lead times for newbuild WTIVs (wind turbine installation vessels) and intense global competition for existing fleet capacity creating potential project delays.

Specialized component supply chains faced challenges scaling production to meet rapidly growing demand. High-voltage subsea cables, dynamic cables for floating wind, advanced power electronics, and large-scale transformers all experienced supply constraints as manufacturers struggled to expand capacity at pace matching project pipelines. Asian manufacturing dominance, particularly Chinese turbine and component production, raised concerns about supply chain resilience and geopolitical dependencies, though Chinese turbines' cost advantages made adoption increasingly likely in price-sensitive markets including floating wind and Southeast Asian developments.

Workforce availability emerged as a binding constraint, with skills gaps threatening deployment timelines across markets. "Inadequate" green skills provision created deficits in critical roles including offshore installation technicians, grid integration specialists, BESS engineers, and project managers, with educational institutions struggling to scale training capacity matching industry needs. Competition for skilled workers intensified between renewable sectors and with traditional energy industries, driving wage inflation and creating recruitment challenges particularly in remote or rural locations hosting major projects.

Regulatory and Permitting Complexity

Despite improvements in European permitting frameworks, regulatory processes remained complex and time-consuming across much of the global market. UK projects still frequently required 3-5 years from application to consent absent OWEIP streamlining, while US federal reviews prior to the Trump administration disruption often exceeded similar timelines. Grid connection processes represented particular bottlenecks, with transmission infrastructure development lagging renewable generation build-out, creating curtailment risks and revenue uncertainty for developers.

Cross-border regulatory harmonization proved challenging despite EU efforts, with member states maintaining divergent approaches to environmental assessments, stakeholder consultation, and financial guarantees. Offshore wind projects spanning multiple jurisdictions faced compounded complexity, while emerging markets lacked institutional capacity for efficient permitting, creating uncertainty deterring investment.

Public opposition and stakeholder conflicts delayed or derailed projects in multiple markets, with fishing industry concerns, visual impact objections, environmental NGO challenges, and military exclusion zones all constraining available development areas. The shift toward more meaningful consultation with tribes, fishing communities, and coastal populations—while democratically important—extended timelines and increased approval uncertainty.

Future Outlook and Strategic Implications

2030 Projections and Long-Term Trajectory

The global offshore low carbon energy sector stands poised for transformative expansion through 2030 and beyond, with projections indicating offshore wind capacity could reach 244 GW globally by decade's end—more than doubling 2025 levels. Europe is forecast to achieve 120 GW with continued leadership from the UK (40.3 GW), Germany (20 GW), and Netherlands (11.4 GW), while Asia-Pacific deployment accelerates to 100+ GW led by China's 58.8 GW installed base expanding through provincial mandates.

North America's trajectory remains uncertain, with 2030 projections ranging from 5 GW to 23 GW depending on federal policy evolution and state-level deployment success. Southeast Asia represents the highest growth potential, with Vietnam, the Philippines, Indonesia, and Thailand collectively targeting 15-20 GW by 2030 if regulatory frameworks continue maturing and financing flows sustain momentum.

Floating offshore wind is projected to reach 16.5 GW operational capacity by 2030, representing approximately 7% of total offshore wind deployment but commanding disproportionate strategic importance for technology development and future growth potential. Scotland, France, Norway, South Korea, and Japan will drive floating deployment through the late 2020s, with China's demonstration projects transitioning to commercial scale and California initiating large-scale floating development.

Green hydrogen production could reach 16.4 million tonnes annually by 2030, with electrolyzer capacity approaching 520 GW globally though less than 4% had entered construction by 2025. The market could potentially reach $700 billion by 2040 with hydrogen meeting up to 24% of global energy demand by 2050, though achieving these projections requires sustained policy support, cost reductions, and offtake agreement proliferation. CCUS capacity is projected to reach 430 Mt CO_2 per year by 2030 and potentially 2,000 Mt by 2050, though substantial acceleration beyond current trajectories is required to align with Net Zero Emissions scenarios.

Integration and System-Level Opportunities

The convergence of offshore wind, hydrogen production, carbon capture, and decommissioning infrastructure creates integrated opportunities transcending individual technology silos. Platform conversion models repurposing end-of-life oil and gas infrastructure for CO_2 injection, hydrogen production, or offshore electrolysis demonstrate how existing assets can support energy transition while reducing costs 40-60% relative to greenfield development. Companies with cross-sector expertise in offshore operations, CCUS, and renewable energy infrastructure are optimally positioned to capture value from these integrated approaches.

Hybrid renewable systems combining offshore wind with battery storage and hydrogen production—demonstrated at Scotland's EMEC facility—validate technical pathways for maximizing generation, minimizing curtailment, and serving industrial offtakers in grid-constrained environments. This model holds particular promise for island and coastal communities, remote industrial sites, and emerging markets lacking robust transmission infrastructure.

Cross-border energy integration through offshore wind-to-hydrogen corridors, interconnected CCUS transport networks, and shared grid infrastructure enables economies of scale, improves system resilience, and optimizes resource utilization across regions. The EU's €240 billion hydrogen grid investment and 100 endorsed PCIs create decade-long structured pipelines for cross-border infrastructure development, while ASEAN Power Grid initiatives target 18 GW of interconnector capacity by 2040 enabling renewable energy trading across Southeast Asia.

Strategic Recommendations for Market Participants

For Supply Chain Companies and Technology Providers:

Develop integrated service offerings spanning multiple offshore low carbon technologies rather than specializing narrowly in single sectors, as platform conversion, hybrid renewable systems, and infrastructure repurposing require cross-sector capabilities. Establish regional presence in high-growth emerging markets including Southeast Asia, with early market entry through partnerships with local engineering firms or development banks creating first-mover advantages. Invest in workforce development, training programs, and apprenticeship schemes addressing critical skills gaps while positioning for sustained growth as deployment accelerates.

Focus capability development on highest-demand specializations including floating wind mooring and anchoring systems, subsea cable design and installation for water depths exceeding 60 meters, hydrogen compression and storage systems, CCUS monitoring and verification technologies, and advanced grid integration solutions. Monitor EU hydrogen PCI project pipeline and position for supply contracts as €240 billion infrastructure investment materializes through 2030s.

For Developers and Project Companies:

Prioritize markets with stable regulatory frameworks, clear procurement mechanisms, and established grid connection processes, concentrating capital deployment where policy visibility reduces execution risk. Pursue corporate PPA strategies providing revenue certainty independent of government support schemes, particularly critical in markets experiencing policy volatility. Develop portfolio diversification across multiple technologies and geographies, reducing exposure to market-specific risks while capturing opportunities in emerging sectors.

Emphasize domestic content commitments and local supply chain development in project bids, aligning with government industrial strategy objectives while improving competitive positioning in CfD auctions and tender processes. Invest early in stakeholder engagement, environmental surveys, and community benefits programs, as "licence to operate" challenges increasingly constrain project approvals across mature markets.

For Financial Institutions and Investors:

Recognize that clean energy investment fundamentals remain robust despite short-term volatility, with structural drivers including decarbonization mandates, energy security imperatives, technological cost reductions, and electricity demand growth supporting long-term capital flows. Develop specialized financing capabilities for emerging technologies including floating wind, green hydrogen, and integrated hybrid systems, as project finance structures, risk profiles, and collateral arrangements differ substantially from fixed-bottom offshore wind.

Monitor sovereign and multilateral development bank co-investment opportunities, particularly EU Hydrogen Bank auctions, Asian Development Bank CCUS financing, and national wealth fund commitments, as blended finance structures de-risk early-stage commercial projects. Evaluate supply chain investment opportunities including port infrastructure, manufacturing facilities, and vessel newbuilds, as these assets generate stable returns while benefiting from government support schemes like UK's FLOWMIS and Clean Industry Bonus mechanisms.

Conclusion: A Sector at Inflection Point

The global offshore low carbon energy sector completed 2025 at a critical inflection point, demonstrating both remarkable momentum and persistent challenges that will shape the industry's trajectory through the decade ahead. Record offshore wind deployment of 19.6 GW, surging investment reaching $80 billion, and maturing hydrogen and CCUS infrastructure validated the sector's commercial viability while establishing foundations for exponential growth. Europe's policy leadership through €240 billion hydrogen grid commitments and 100 endorsed Projects of Common Interest, combined with Asia-Pacific's accelerating regulatory frameworks in Vietnam, the Philippines, and Taiwan, created structured long-term pipelines supporting sustained capital deployment and technology development.

Yet significant barriers remain. Supply chain constraints across cables, installation vessels, and specialized components threaten deployment timelines, while skills gaps in critical roles from offshore technicians to grid integration specialists constrain workforce availability. Cost pressures persisting from 2023-2024 inflation and interest rate rises continue challenging project economics, forcing developers toward greater selectivity and potentially delaying marginal projects. US policy hostility created profound market disruption, with BOEM's rescission of all designated Wind Energy Areas and multiple project cancellations undermining what should have been the Western Hemisphere's largest offshore wind market.

The sector's future depends critically on maintaining policy consistency, accelerating supply chain development, closing skills gaps through targeted training investment, and achieving cost reductions through technological innovation and economies of scale. Companies that develop integrated capabilities spanning multiple offshore low carbon technologies, establish early presence in high-growth emerging markets, and invest in workforce development will capture disproportionate value as the energy transition accelerates. Financial institutions recognizing clean energy's structural drivers and developing specialized financing capabilities for emerging technologies will benefit from sustained investment opportunities through 2030 and beyond.

The offshore low carbon energy sector demonstrated in 2025 that the transition from fossil fuels to clean energy systems is not merely aspirational but actively underway, supported by record investment, advancing technology, and deepening policy commitment across the majority of global markets. The question is no longer whether this transition will occur, but rather how rapidly it can scale to meet mid-century decarbonization imperatives while creating sustainable economic opportunities for workers, communities, and regions worldwide.

Dr Jim Hamill

Please see below for a comprehensive list of references used in the compilation of this report.

References

1. Energy-Transition-Weekly-Vol-1-No-2-12th-Dec-2025.pdf
2. Energy-Transition-Weekly-Global-Edition-Vol-1-No-1.pdf
3. https://www.rystadenergy.com/news/global-offshore-wind-landmark-19gw
4. https://strategicenergy.eu/the-offshore-wind/
5. https://www.renewableuk.com/news-and-resources/press-releases/global-operational-offshore-wind-capacity-up-14-in-last-12-months-to-85-gigawatts/
6. https://brazilenergyinsight.com/2025/08/04/global-offshore-wind-capacity-reaches-83-gw-100-gw-more-to-be-awarded-in-2025-2026-new-report-says/
7. https://www.startus-insights.com/innovators-guide/global-offshore-wind-report/
8. https://www.iigcc.org/insights/world-energy-investment-2025-highlights-electricity-demand-and-energy-security-new-drivers
9. https://theextractormagazine.com/2025/10/24/over-1500-green-hydrogen-projects-announced-across-70-countries/
10. https://eurometal.net/global-hydrogen-investment-to-jump-70-in-2025-despite-project-delays/
11. https://www.soci.org/news/2025/5/ccus-carbon-capture-is-growing-but-there-is-still-much-to-do
12. https://www.renewableuk.com/our-work/offshore-wind/
13. https://www.renewableuk.com/energypulse/reports/floating-offshore-wind-pipeline-report-november-2025/
14. https://windeurope.org/windeurope-bulletin/september-2025/
15. https://www.offshorewindscotland.org.uk/news/2025/july/24/salamander-floating-wind-project-consented-by-scottish-ministers/
16. https://www.offshorewindscotland.org.uk/news/2025/july/31/worlds-largest-offshore-wind-project-berwick-bank-gets-scottish-government-green-light/
17. https://www.renewableenergyworld.com/wind-power/offshore/us-overhauling-offshore-wind-rules-to-align-with-trump-priorities/

18. https://www.renewableenergyworld.com/wind-power/offshore/gigawatts-gone-another-major-offshore-wind-developer-stops-work-in-the-us/

19. https://www.renewableenergyworld.com/wind-power/offshore/us-offshore-wind-long-dead-now-really-dead/

20. Energy-Transition-Weekly-ASEAN-Vol1-No1.pdf

21. https://www.offshore-windindustry.com/news/wind/article-6912-offshore-wind-expansion-in-taiwan-gains-momentum-peak-wind-secures-operational-management-for-495-mw-fengmiao-i-wind-farm

22. https://www.nortonrosefulbright.com/en/knowledge/publications/1a59df58/the-next-frontier-offshore-wind-development-in-asia

23. https://www.offshorewindscotland.org.uk/news/2025/march/6/port-of-cromarty-firth-secures-55m-flowmis-funding/

24. https://www.offshorewindscotland.org.uk/news/2025/april/24/prime-minister-launches-300m-boost-for-offshore-wind-industry/

25. https://www.offshore-windindustry.com/news/wind/article-7144-nordex-share-jumps-to-top-of-renixx-strong-demand-for-nordex-wind-turbines-in-france-and-belgium-conditional-order-of-around-1000-mw-in-the-us-in-focus

26. https://www.precedenceresearch.com/hydrogen-market

27. https://climateinsider.com/2024/09/02/green-hydrogen-companies/

28. https://www.blackridgeresearch.com/blog/latest-list-of-largest-biggest-green-hydrogen-h2-projects-plants-in-the-world

29. https://www.startus-insights.com/innovators-guide/hydrogen-economy-outlook/

30. Energy_Transition_Weekly_Vol1_No1.pdf

31. https://www.airswift.com/blog/green-hydrogen-projects-usa

32. https://carboncredits.com/hydrogen-in-2025-the-journey-through-progress-pitfalls-and-policy-shifts/

33. https://cib.bnpparibas/the-future-of-carbon-capture-and-storage-strategies-and-challenges/

34. https://www.enverus.com/blog/ccus-play-fundamentals-the-high-cost-of-clean-air/

35. https://earthfest.world/uk-climate-tech-in-2025

36. https://www.woodmac.com/news/opinion/the-forces-shaping-the-future-of-carbon-management/

37. https://ieaghg.org/news/delivering-the-next-phase-of-ccus-key-takeaways-from-day-one-of-the-ccus-2025-conference/

38. https://www.weforum.org/press/2025/09/turning-carbon-into-value-report-charts-carbon-capture-and-utilization-pathways-for-growth-and-emissions-abatement/

39. https://www.offshorewindscotland.org.uk/news/2025/october/27/buchan-offshore-wind-submits-onshore-consent-application/

40. https://www.offshorewindscotland.org.uk/news/2025/september/10/aspen-planning-application-milestone/

41. https://www.offshorewindscotland.org.uk/news/2025/june/4/multi-million-investment-for-floating-wind-at-kishorn-port/

42. https://www.oceanwinds.com/news/uncategorized/ocean-winds-to-develop-third-floating-offshore-wind-site-in-the-celtic-sea/

43. https://www.offshorewindscotland.org.uk/the-offshore-wind-market-in-scotland/floating-wind-in-scotland/

44. https://greenvoltoffshorewind.com/project-overview/

45. https://commercial.allianz.com/news-and-insights/expert-risk-articles/offshore-energy-generation-2025.html

46. https://op.europa.eu/webpub/mare/eu-blue-economy-report-2025/blue-economic-sectors/marine-renewable-energy.html

47. https://www.offshore-windindustry.com/news/wind/article-7074-wood-mackenzie-analysis-renewable-energy-to-reach-record-low-global-lcoe-in-2025

48. https://www.futuremarketinsights.com/reports/offshore-wind-market

49. https://www.renewableenergyworld.com/wind-power/offshore/great-britain-could-have-12-6-gw-of-wave-and-tidal-energy-deployments-by-2050/

50. https://www.waveenergyscotland.co.uk/news/2025/june/uk-government-launches-marine-energy-taskforce-to-accelerate-wave-and-tidal-innovation/

51. https://pulseenergy.io/blog/renewable-energy-investment-shaping-a-sustainable-2025-energy-future

52. https://about.bnef.com/insights/clean-energy/global-renewable-energy-investment-reaches-new-record-as-investors-reassess-risks/

53. https://www.cognitivemarketresearch.com/offshore-wind-energy-market-report

54. https://www.offshorewindscotland.org.uk/news/2025/november/10/owgp-launch-industrial-growth-fund/

55. https://www.offshore-windindustry.com/news/wind/article-7091-strong-third-quarter-nordex-significantly-increases-profit-in-q3-2025-share-reacts-cautiously

56. https://www.offshorewindscotland.org.uk/news/2025/february/25/how-innovation-drives-offshore-wind-supply-chain-growth/

57. https://www.neuwave.co.uk/2025/06/03/policy-changes-and-impacts-on-offshore-wind-developments-in-2025/

58. https://www.offshorewindscotland.org.uk/news/2025/october/27/sim-confirms-transition-plan-following-successful-completion-of-stage-2/

59. https://www.offshorewindscotland.org.uk/news/2024/january/11/10-000-offshore-wind-jobs-in-scotland/

60. https://www.offshorewindscotland.org.uk/skills-for-offshore-wind/

61. https://www.astutepeople.co.uk/blog/2025/07/17/top-10-skills-for-uk-renewable-energy-jobs-in-2025/

62. https://www.imperial.ac.uk/energy-futures-lab/reports/briefing-papers/net-zero-skills--jobs-skills-and-training-for-the-net-zero-energy-transition/

63. https://www.offshorewindscotland.org.uk/skills-for-offshore-wind/transition-pathway/transition-support/

64. https://www.skillsdevelopmentscotland.co.uk/news-events/2025/july/oil-and-gas-transition-training-fund-offers-pathway-to-clean-energy-jobs/

65. https://www.offshorewindscotland.org.uk/the-scottish-offshore-wind-industry/sowec/sowec-publications/sowec-skills-guide/

66. https://www.offshorewindscotland.org.uk/media/v3hbtyv3/sowec-skills-guide-february-2025.pdf

67. https://www.airswift.com/blog/top-transferrable-skills-in-energy

68. https://www.key-expo.com/en/news-detail/jobs-in-the-energy-transition?newsId=6237480

69. https://www.gov.scot/publications/draft-updated-sectoral-marine-plan-offshore-wind-energy-2025/pages/11/

70. https://www.gov.scot/publications/draft-updated-sectoral-marine-plan-offshore-wind-energy-2025/pages/12/

71. https://www.gov.uk/government/consultations/planning-for-new-energy-infrastructure-2025-revisions-to-national-policy-statements/outcome/2025-revisions-to-national-policy-statements-government-response-accessible-webpage

72. https://www.renewableenergyworld.com/wind-power/offshore/trump-administration-issues-order-to-stop-construction-on-new-york-offshore-wind-project/

73. https://www.renewableenergyworld.com/wind-power/offshore/cec-adopts-plan-for-25-gw-of-offshore-wind-by-2045/

74. https://www.offshore-windindustry.com/news/wind/article-7070-wind-market-in-romania-gains-momentum-major-order-for-ge-vernova-and-stable-expansion-forecasts-through-2030

75. https://www.offshorewindscotland.org.uk/media/12632/repurposing-oil-and-gas-infrastructure-report.pdf

76. https://www.businesswire.com/news/home/20250321348708/en/Global-Hydrogen-Market-Report-2025-2035-with-Profiles-of-Over-280-Companies-Across-the-Hydrogen-Value-Chain---ResearchAndMarkets.com

77. https://www.bcg.com/publications/2025/offshore-wind-industry-update

78. https://www.renewableenergyworld.com/wind-power/offshore/gwec-offshore-wind-is-estimated-to-surge-to-234-gw-by-2030/

79. https://www.renewableenergyworld.com/wind-power/offshore/floating-offshore-wind-where-does-the-industry-stand/

80. https://www.offshorewindscotland.org.uk/media/41kbhtps/sowec-annual-review.pdf

81. https://www.offshore-windindustry.com

82. https://www.offshore-windindustry.com/news/wind/article-7071-green-boost-for-europes-power-mix-renewables-dominate-iberdrolas-electricity-mix-from-january-to-september-2025-with-86-percent

83. https://www.offshorewindscotland.org.uk/the-scottish-offshore-wind-industry/sowec/sowec-publications/

84. https://www.offshore-windindustry.com/news/wind/article-6993-nordex-impresses-in-q2-2025-strong-order-intake-increased-profitability-positive-cash-flow-stock-climbs

85. https://www.offshore-windindustry.com/news/press-releases/pm-8541-half-year-results-pne-ag-reports-operational-success-in-h1

86. https://www.researchandmarkets.com/reports/5766768/offshore-wind-market-report

87. https://www.oceanwinds.com/news/uncategorized/for-its-five-years-anniversary-ocean-winds-goes-beyond-energy-at-windeurope-2025-reinforcing-its-commitment-to-a-sustainable-future/

88. https://www.energy.gov/eere/wind/offshore-wind-market-report

89. https://www.reuters.com/markets/commodities/wind-energy-blown-off-course-2025-set-2026-uplift-2025-12-23/

90. https://www.irena.org/News/articles/2025/Sep/Offshore-Wind-From-83-GW-Today-to-2000-GW-by-2050

91. https://w3.windfair.net/wind-energy/news/47575-download-gwec-s-global-offshore-wind-report-2025

92. https://www.aegirinsights.com/2025-global-market-forecast-steady-offshore-wind-build-out-across-regions-until-2040

93. https://www.gwec.net

94. https://www.connaissancedesenergies.org/sites/connaissancedesenergies.org/files/pdf-actualites/GOWR-2024_digital_final_2.pdf

95. https://www.offshore-windindustry.com/news/press-releases/pm-8722-communal-agreement-reached-for-bertikow-battery-storage-facility

96. https://www.offshore-windindustry.com/news/press-releases/pm-8400-enertrag-launches-auction-for-500-tons-of-green-hydrogen-at-e-world-2025

97. https://www.offshorewindscotland.org.uk/media/12669/power2x-subgroup-27th-of-may.pdf

98. https://www.offshore-windindustry.com/news/press-releases/pm-8663-groundbreaking-ceremony-for-the-enertrag-hydrogen-plant-in-wensickendorf-laying-the-foundation-for-sustainable-mobility

99. https://www.offshorewindscotland.org.uk/media/12668/power2x-subgroup-18th-of-feb.pdf

100. https://www.offshore-windindustry.com/news/press-releases/pm-8527-repowering-and-expansion-sonnenberg-v-wind-farm-becomes-a-landmark-project-enertrag-and-ebert-sign-cooperation-agreement

101. https://www.offshore-windindustry.com/news/wind/article-6784-ramp-up-of-h2-economy-in-europe-pne-receives-green-light-from-eu-commission-to-review-hydrogen-production-project

102. https://www.offshore-windindustry.com/news/wind/article-7026-vattenfall-expands-germanys-largest-offshore-wind-farm-nordlicht-from-eemshaven-port-becomes-hotspot-for-offshore-wind-energy-and-green-hydrogen

103. https://www.offshore-windindustry.com/news/world/article-6222-iea-report-global-energy-crisis-becomes-expansion-booster-for-renewables

104. https://www.offshore-windindustry.com/news/press-releases/pm-8426-enertrag-and-partners-celebrate-the-successful-implementation-of-powersystem-in-bolivia-and-welcome-the-bolivian-delegation-to-dauerthal

105. https://www.offshore-windindustry.com/news/wind/article-7149-stock-market-week-50-25-renixx-in-the-red-array-technologies-and-nordex-rise-double-digits-bloom-energy-under-pressure

106. https://www.offshore-windindustry.com/news/wind/article-7120-stock-market-week-47-25-renixx-deep-in-the-red-canadian-solar-bloom-energy-daqo-xpeng-and-array-technologies-with-double-digit-losses

107. https://www.offshore-windindustry.com/news/press-releases/pm-8434-abo-energy-strengthens-basis-for-profit-growth

108. https://www.offshore-windindustry.com/news/wind/?land=Finland

109. https://www.renewableenergyworld.com/wind-power/offshore/exploring-europes-approach-to-offshore-wind-and-green-hydrogen/

110. https://www.offshore-windindustry.com/news/wind/article-6987-masdar-and-iberdrola-invest-billions-in-uk-and-german-offshore-wind-energy

111. https://www.offshore-windindustry.com/news/press-releases/pm-8346-encavis-acquires-wind-farms-from-enertrag-in-bonnhagen-and-roitzsch

112. https://www.globenewswire.com/news-release/2025/06/03/3092520/0/en/Hydrogen-Economy-Industry-Research-Report-2025-2045-Fusion-Power-s-Big-Promise-Green-Hydrogen-as-the-Modern-Answer-to-Strategic-Reserves.html

113. https://www.businesswire.com/news/home/20250603055142/en/Hydrogen-Economy-Reinvented-Research-Report-2025-Materials-and-Hardware-Market-Analysis-Technology-Dynamics-and-Long-term-Forecasts-to-2045---ResearchAndMarkets.com

114. https://www.cliffordchance.com/content/dam/cliffordchance/briefings/2025/03/focus-on-hydrogen-state-of-the-market-2025.pdf

115. https://cen.acs.org/energy/hydrogen-power/Green-hydrogen-still-making-gains/103/web/2025/05

116. https://www.offshore-windindustry.com/news/wind/article-6991-record-investment-saudi-arabia-commits-83-billion-to-15000-mw-of-wind-and-solar-capacity

117. https://www.offshore-windindustry.com/news/nachrichten/artikel-7086-stock-market-week-44-25-renixx-new-yearly-high-canadian-solar-bloom-energy-first-solar-and-nordex-with-double-digit-gains-enphase-disappointing-outlook-plug-power-expands-business-fields

118. https://www.renewableenergyworld.com/wind-power/offshore/trump-administration-suspends-5-wind-projects-off-the-east-coast/

119. https://www.renewableenergyworld.com/wind-power/offshore/federal-judge-throws-out-trump-order-blocking-development-of-wind-energy/

120. https://www.offshore-windindustry.com/news/wind/article-7146-strong-interest-in-ready-to-build-wind-projects-exus-deepens-its-presence-in-the-german-wind-market-with-acquisition-of-69-mw-wind-farm-project

121. https://www.deloitte.com/gr/en/Industries/power-utilities-renewables/perspectives/2025-renewable-energy-industry-outlook.html

122. https://www.thecrownestate.co.uk/our-business/marine/round-5

123. https://assets.publishing.service.gov.uk/media/69127167ece74c08fbaa646f/appraisal-of-sustainability.pdf

124. https://www.weforum.org/stories/2025/09/the-top-5-energy-technology-trends-of-2025/

125. https://oeuk.org.uk/policy-reform-can-herald-a-new-chapter-for-offshore-energy-industry/

126. https://about.bnef.com/insights/finance/energy-transition-investment-trends/

127. https://www.renewableuk.com/media/bfcjsiwa/developing-effective-end-of-life-policy-frameworks-for-uk-offshore-wind.pdf

128. https://www.crownestatescotland.com/sites/default/files/2025-06/OSW Sector Profile. May 2025.pdf

129. https://kpmg.com/xx/en/our-insights/esg/energy-transition-investment-outlook-2025-and-beyond.html

130. https://www.renewableenergyworld.com/wind-power/offshore/grand-passage-tidal-energy-system-ready-for-commercial-operation/

131. https://www.renewableenergyworld.com/wind-power/offshore/sustainable-marine-energy-reveals-plans-for-9-mw-pempaq-tidal-energy-project/

132. https://www.offshorewindscotland.org.uk/news/2024/november/08/sowec-skills-group-seeks-next-generation-of-talent-at-careers-fairs/

133. https://www.renewableenergyworld.com/wind-power/offshore/perpetuus-tidal-energy-orbital-marine-sign-tidal-energy-agreement/

134. https://www.offshorewindscotland.org.uk/the-scottish-offshore-wind-industry/sowec/strategic-investment-model/

135. https://oceantic.org/press-releases/supply-chain-roadmap-for-offshore-wind/

136. https://www.guiceoffshore.com/offshore-wind-supply-chain-roadmap-development-next-step-for-federal-state-offshore-wind-implementation-partnership/

137. https://www.nature.scot/professional-advice/planning-and-development/planning-and-development-advice/renewable-energy/marine-renewables/wave-and-tidal-energy

138. https://supply-chain-spotlight.co.uk

139. https://www.thecrownestate.co.uk/news/new-marine-energy-taskforce-launched-with-backing-from-the-crown-estate-and-crown-estate-scotland

140. https://www.renewableuk.com/news-and-resources/press-releases/offshore-wind-farm-developers-offer-millions-in-funding-to-new-uk-supply-chain-companies/

141. https://www.globalunderwaterhub.com/events/event/?id=Marine_Energy_20251074039276

142. https://ore.catapult.org.uk/capabilities/supply-chain-growth/spotlight-supply-chain

143. https://www.elmhurstenergy.co.uk/blog/2025/11/06/the-governments-clean-energy-jobs-plan-what-it-means-for-skills-and-training/

144. https://www.ukri.org/what-we-do/browse-our-areas-of-investment-and-support/marine-wave-and-tidal/

145. https://www.carbontrust.com/our-work-and-impact/guides-reports-and-tools/marine-energy

146. https://oeuk.org.uk/product/supply-chain-report-2025/

147. https://ppl-ai-file-upload.s3.amazonaws.com/web/direct-files/collection_b4c0e730-57df-4b5d-a30c-63ddcd093c26/398e30d2-f844-48e8-963e-4cd5903c59b2/Unlocking-ASEAN-Low-Carbon-Market-Opportunities-Final-Version.pdf

148. https://ppl-ai-file-upload.s3.amazonaws.com/web/direct-files/collection_b4c0e730-57df-4b5d-a30c-63ddcd093c26/634fbecc-d30d-46f2-aa63-d7f1492645df/Offshore-Low-Carbon-Market-Opportunities-in-Vietnam.pdf

149. https://ppl-ai-file-upload.s3.amazonaws.com/web/direct-files/collection_b4c0e730-57df-4b5d-a30c-63ddcd093c26/fab70d6e-1233-435a-89a9-57bfbc8291cb/Offshore-Low-Carbon-Energy-Projects-Contracts-in-Vietnam.pdf

150. https://ppl-ai-file-upload.s3.amazonaws.com/web/direct-files/collection_b4c0e730-57df-4b5d-a30c-63ddcd093c26/0ee61136-806b-4ba5-8ef7-64a09b7841db/Low-Carbon-Market-Opportunities-in-the-ASEAN-Region.pdf

151. https://ppl-ai-file-upload.s3.amazonaws.com/web/direct-files/collection_b4c0e730-57df-4b5d-a30c-63ddcd093c26/a4b9a0e7-4d32-4bc7-a5c0-2bd93113c0fc/ASEAN-Low-Carbon-Energy-Projects-Contracts.pdf

152. https://ppl-ai-file-upload.s3.amazonaws.com/web/direct-files/collection_b4c0e730-57df-4b5d-a30c-63ddcd093c26/f8c606c2-a53b-4f8a-8535-dc11470734d1/please-provide-a-list-of-the-m-Y7qVduLaS5WymLhQJWDO.w.md

153. https://ppl-ai-file-upload.s3.amazonaws.com/web/direct-files/collection_b4c0e730-57df-4b5d-a30c-63ddcd093c26/85a449c3-f1bb-48ca-926f-7f88312b9595/Market-Intelligence-Opportunity-Identification_-1.docx

154. https://ppl-ai-file-upload.s3.amazonaws.com/web/direct-files/collection_b4c0e730-57df-4b5d-a30c-63ddcd093c26/309b50e3-85e8-4b6d-9807-4c991c56bd7f/TOOLKIT-2_-YOUR-AI-READINESS-TO-EXPORT-AI-TOOLKIT.docx

155. https://ppl-ai-file-upload.s3.amazonaws.com/web/direct-files/collection_b4c0e730-57df-4b5d-a30c-63ddcd093c26/0990bb77-4f7c-4579-88eb-43651b480f34/Detailed-Summary-of-Toolkit-3_-Your-AI-Supported-E.docx

156. https://ppl-ai-file-upload.s3.amazonaws.com/web/direct-files/collection_b4c0e730-57df-4b5d-a30c-63ddcd093c26/2fa29b95-d5d7-4201-8071-ba563ef8e5a1/Toolkit-2-Your-Export-Readiness-Evaluation-3-1-4.docx

157. https://ppl-ai-file-upload.s3.amazonaws.com/web/direct-files/collection_b4c0e730-57df-4b5d-a30c-63ddcd093c26/b9cf213f-62c8-406d-b127-f8812b4ea7c7/Toolkit-3-Your-Export-Strategy-Toolkit-7.docx

158. https://ppl-ai-file-upload.s3.amazonaws.com/web/direct-files/collection_b4c0e730-57df-4b5d-a30c-63ddcd093c26/4e34a9e4-89a3-4664-b469-efe1060b6a1b/Toolkit-4-A-QCGP-for-Export-Markets.pdf

159. https://ppl-ai-file-upload.s3.amazonaws.com/web/direct-files/collection_b4c0e730-57df-4b5d-a30c-63ddcd093c26/fd4b1192-b11e-4d18-971c-40c6dab92bb7/TOOLKIT-5-Customer-Persona-Development-and-Conte.docx

160. https://ppl-ai-file-upload.s3.amazonaws.com/web/direct-files/collection_b4c0e730-57df-4b5d-a30c-63ddcd093c26/10c9b2be-99b4-427d-906e-b9c9da3e6db0/Why-North-Sea-Energy-Companies-Must-Accelerate-Glo.pdf

161. https://www.offshorewindscotland.org.uk/media/12628/sowec-guide-for-scottish-exporters.pdf

162. https://www.renewableenergyworld.com/wind-power/offshore/asia-offshore-wind-boom-lures-japanese-trading-houses/

163. https://www.offshorewindscotland.org.uk/media/r3rp3du2/sowec-innovation-guide-january-2025.pdf

164. https://www.offshorewindscotland.org.uk/news/2025/march/25/sowec-launches-its-annual-review/

165. https://www.offshore-windindustry.com/wind-farms

166. https://www.woodmac.com/lens/lens-wind/