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INFRASTRUCTURE

June 2024

U.S. offshore wind:
Blowing in the right direction

OPINION PIECE. PLEASE SEE IMPORTANT DISCLOSURES IN THE ENDNOTES.

By 2050, wind is expected to generate...

~50%
of on-grid electricity in Europe

~40%
in the Americas

~33%
of electricity generation in Greater China

According to the Global Wind Energy Council (GWEC) we are likely to reach 328 GW globally of installed offshore wind capacity by 2030, as long as governments commit to implementing policies to shore up global supply chains and address permitting challenges.[1]

The share of offshore wind in total global wind electricity generation is expected to increase steadily, surpassing onshore wind and rising from 8% in 2020 to 34% in 2050.

Of this figure, 6% is projected to be floating offshore.[2] Operational offshore wind capacity is forecast to reach 447 gigawatts (GW) worldwide by 2032 – a seven-fold increase relative to 30 June 2023.[3] Offshore wind is still nascent in the U.S. compared to Asia and Europe: Asia-Pacific's total installed offshore wind capacity reached 34 GW in 2022, surpassing Europe's 30 GW, with nearly all APAC capacity concentrated in China.[4] In contrast, until December 2023, there were no commercial-scale plants operating in the U.S., and less than 1 GW under construction. In Q1 2024, Vineyard Wind 1 became just the first U.S. commercial scale project with a capacity of 806MW that connected its first turbines to the grid.

Although there is only 932 megawatts (MW) under construction, the industry boasts over 40 GW in the project pipeline.[5] In December 2023, Danish developer Ørsted and the U.S. utility Eversource celebrated the first power delivered to New York by South Fork Wind farm. South Fork is fully commissioned as of March 2024. While other commercial projects are yet to start generating electricity, there are several large scale now under construction and two smaller scale offshore wind projects in operation – consisting of seven turbines off Rhode Island and Virginia, with a combined capacity of 42 MW.[6]

The expected growth of the U.S. offshore wind industry will be motivated by investors' recognition of the strong potential of the market, guided by the Biden-Harris Administration's current goals. These goals include:[7]

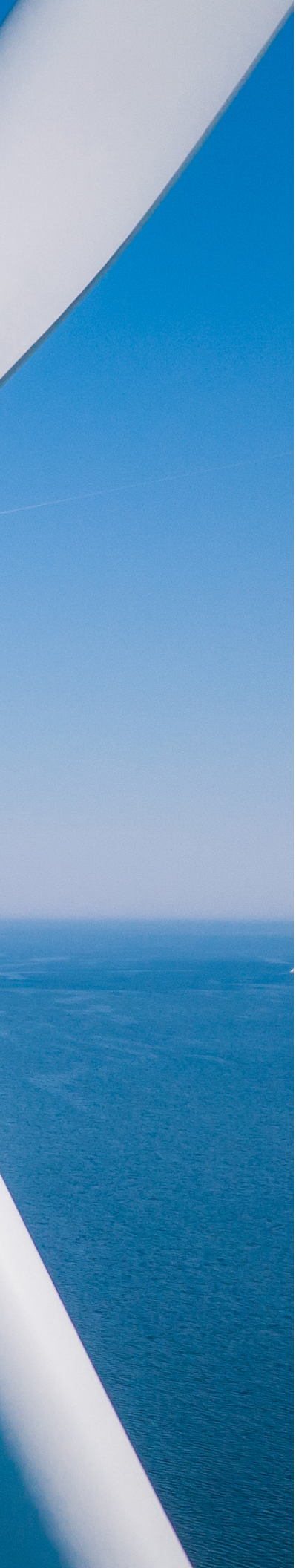
- **30 GW** of offshore wind capacity in U.S. waters by 2030
- **15 GW** of floating offshore wind by 2035
- **100%** clean energy grid by 2035[8]
- **Progress towards 110 GW** by 2050[9]

The Inflation Reduction Act 2022 (IRA) is the single biggest climate action investment ever made and is expected to drive the expansion of renewable energy in the U.S. over the next 10 years, turbocharging the U.S. renewables market and providing momentum for the U.S. offshore wind industry.[10] The new law is already mobilising huge investment into renewable generation, decarbonized transport, energy storage and improved grid connections.[11] The Act significantly expands tax credits for offshore wind and related technologies. Consequently, since the IRA was signed into law in August 2022, investments in the U.S. offshore wind industry have increased by $7.7 billion and the number of companies looking to support this supply chain has risen 54% to 4,100 companies across all 50 states.[12] The Administration's efforts to drive long-term growth across the offshore wind industry also include site-leasing and much-needed permitting reforms, Department of Energy (DOE) initiatives to build domestic supply chains, and the improvement of infrastructure for transmission, construction and maintenance.

While there are signs that the offshore wind industry is growing, there are also significant concerns and challenges to overcome. The supply chain must be strengthened, and infrastructure of this scale requires substantial upfront investment in a climate of rising financing costs. Both Europe and the U.S. face the risk of supply chain shortfalls in key commodities such as copper, steel and rare earth elements (REEs), power transmission equipment, wind turbines and offshore installation vessels. The struggle to keep up with demand could be exacerbated by protectionist manufacturing policies. However, there are also benefits to this approach, as shoring up local manufacturing and creating jobs is more likely to foster bipartisan support for the wind industry in the U.S., in turn encouraging greater political ambition and more investment in the sector.

Recent turbulence of capex cost, interest rates and electricity pricing resulted in some projects being delayed or abandoned altogether. The problem now faced by U.S. policy makers is how to readjust the market to keep up momentum in the offshore wind industry. Many manufacturers have seen mounting financial losses caused by 'race to the bottom' pricing. This is largely a result of government policies around procurement and offtake arrangements, exacerbated by higher inflation and logistics costs. Meanwhile, wind projects have been delayed or stalled by inadequate and inefficient permitting and licensing rules.[13] As the cost of turbines, cables and financing rises sharply, developers need to be able to secure higher power prices to make investments viable.[14]

Offshore wind potential in the U.S.



Role played by offshore wind in energy transition and decarbonization goals

Offshore wind will play an important role in the U.S. energy transition and in meeting the target of a clean energy grid by 2035. Wind is a plentiful, under-utilized resource, and with higher capacity factors and technological improvements, is expected to be a cornerstone of renewable energy production. The U.S. has the potential for large capacity offshore wind farms, but the ambitious goals set by federal and state governments must be met with ambitious investment. The current incentives for developers are impressive, with IRA tax credits, additional government programs and concerted efforts to build domestic supply chains and reduce costs. In addition to greater generation capacity, offshore wind should be able to efficiently supply coastal cities that have less access to solar PV and onshore wind. Governments, energy companies and industrial end users – such as chemical companies and steel producers – are also increasingly looking at offshore wind as a power source to produce hydrogen that can be used in other sectors of the economy as a zero-emission fuel.[15]

Offshore wind energy remains expensive in comparison to onshore wind and solar. While it is true that costs have fallen, the second half of 2023 proved difficult for the industry, and struggles on the supply chain and price increases on raw materials have translated into some projects being cancelled or power purchase agreements being renegotiated. The levelized cost of electricity (LCOE) for bottom-fixed foundations in mature markets like Europe is expected to decrease at less pace than in the previous decade. By 2027 we see a slight increase in the LCOE curve, and then a continued decrease after the market has adjusted. Less mature markets like the U.S., Japan and South Korea, have more room for LCOE reduction on the range of 40% by 2035. Floating wind is less mature than bottom-fixed, and we therefore expect the decrease in the LCOE to be much steeper over the next decade, with reductions up to 50% as economies of scale and technological refinement take effect. There are multiple floater designs and concepts in the market, and a natural next step will include technology standardization and modular production. This will lead to a continued reduction in the LCOE of floating wind.[16]

In March 2023, the U.S. DOE set out a strategy to advance offshore wind. The aim is to deploy 30 GW of offshore wind energy by 2030 and to set the U.S. on a pathway to 110 GW or more by 2050. This supports the Administration's goal of 15 GW of floating offshore wind by 2035.[17] Targets include reducing the cost of bottom-fixed offshore wind to $51/megawatt-hour (MWh) by 2030 and reducing the cost of floating offshore wind energy in deep waters far from shore to $45/MWh by 2035.

Recent measures (as of September 2023) consist of:

- Securing an East Coast Memorandum of Understanding (MOU) on Offshore Wind Supply Chain Collaboration
- Launching an Atlantic Offshore Wind Transmission Action Plan
- Awarding $72 million to wind energy innovation projects, including new manufacturing processes for wind turbine equipment, such as using 3D printing to make large turbine blades, and projects advancing high-voltage direct current (HVDC) transmission technologies for offshore wind. [18]

Incentives under the Inflation Reduction Act: PTC, ITC and energy communities bonus credit

The IRA extends the production tax credit (PTC) and investment tax credit (ITC) for wind and solar through 2024 before transitioning to a technology-neutral tax credit that will remain in place until 2032, or when electric-sector emissions fall to 75% of 2022 levels. The legislation introduces a new clean energy component manufacturing PTC – providing energy transition equipment manufacturers with a component-specific tax credit for each unit produced domestically.[19] This new support for domestic manufacturing should encourage a strong domestic supply chain for both onshore and offshore wind.

Along with the ITC and PTC, under the special energy community rule of the IRA, offshore wind projects with onshore interconnection facilities in a qualifying census tract, metropolitan/nonmetropolitan statistical area or brownfield site are eligible for another 10% tax credit. This brings IRA-related tax breaks to at least 40% of project costs — and a maximum of 50% when some domestic component quotas are met. S&P Global Commodity Insights estimates that more than 28% of the continental U.S. shoreline is bordered by energy communities.[20]

The development of new manufacturing facilities, processing plants and raw material production aims to insulate the U.S. from geopolitical supply chain risks.[21] Because of these incentives, currently idle component facilities are considering restarting production, and equipment providers to the offshore wind industry are pursuing plants along the East Coast. In February and March 2023, Siemens Gamesa and General Electric announced intentions to build offshore wind nacelle manufacturing plants on the East Coast.[22]

Risks and challenges

There are a number of risks and challenges for offshore wind developers, moreso because of the nascency of the industry in the U.S. They must consider weather-related and technical issues, alongside political volatility and the nascent supply chain and infrastructure for offshore wind. There is also little experience with maintaining offshore wind farms in the U.S. Other hurdles include finding skilled labor and gaining approval for permits – costs that developers and equipment manufacturers need to recuperate.[23]

It is unclear how fast U.S. supply chains can adapt to take advantage of the IRA, and whether they will be able to grow at the scale and pace needed to keep up with demand. The U.S. has manufacturing capacity to supply most domestic demand for onshore turbine equipment to 2031, but the country is at a standing start for supplying offshore wind.[24]

Supply chain bottlenecks have been pronounced for several reasons. Firstly, the concentration of tier 1 turbine components in just a few manufacturers, most of them based abroad. Secondly, the difficulty of shipping extra-large wind turbine components, especially with steep increases in shipping costs from 2022 onwards. Thirdly, the current scarcity of suitable vessels and ports for deploying offshore wind. Much is being invested in ports and expanded

installation and maintenance fleets, so this should be alleviated in the long term.[25] However, increasing demand for equipment and the rising price of key commodities (such as copper and steel) needed to produce components will place significant pressure on supply chains.

Another risk area – which tripped up several projects in 2023 – is in securing offtake at profitable levels. Because capex for the first round of full-scale projects will be higher, this needs to be balanced with strong PPA prices to ensure a final investment decision can be confidently taken. There were several recent instances of projects which signed offtake agreements prior to the recent spikes in inflation, commodity prices and interest rates. In light of these higher costs, the project economics broke down and some projects were either dropped or delayed in order to negotiate new offtake agreements.[26] Utilities have proved willing to pay a premium for the clean power from these wind farms, but this must also be balanced with not placing an outsized burden on rate payers. Already in early 2024 there have been several PPAs signed at higher levels that can support the new project costs.[27] This is an encouraging sign that the different stakeholders in the industry are adjusting to the market conditions in an effective way to keep momentum moving ahead.

Potential market size

In theory, the National Renewable Energy Laboratory (NREL) analysis estimates a potential capacity of 1,476 GW (4,595 TWh) of total fixed-bottom capacity and 2,773 GW (8,972 TWh) of floating capacity for the contiguous U.S. coastline.[28] This could meet the nation's electricity demand three times over. The U.S. has only just begun to make use of the enormous resource potential along its coasts with seven turbines (42 MW) installed off Rhode Island and Virginia. In addition to the federal offshore wind target of 30 GW by 2030 and 15 GW of floating offshore wind by 2035, individual state policies aim to procure at least 39 GW by 2040.[29]

Current state of the market – contrast to European market

The U.S. offshore wind market is very underdeveloped, with 972 MW of operating capacity compared to 32 GW of capacity in Europe. The latter continues to lead the way on floating wind, with Norway commissioning 60 MW of floating wind in 2022, bringing the region's total installations to 171 MW and equalling 91% of global installations.[30]

The U.S. federal government under the Biden-Harris Administration is looking to accelerate offshore wind. The electricity sector is expected to make the largest contribution to the economy-wide emission reductions target of 50-52% this decade and the goal of a net zero emissions grid by 2035. Wind energy – both onshore and offshore – is critical to achieving this, and annual wind additions are expected to double from around 10 GW per year today to over 20 GW by 2030.[31]

In May 2022 the U.S. Administration released a Permitting Action Plan and in October 2023 the Federal Permitting Improvement Steering Council (Permitting Council) announced the allocation of nearly $155 million to help federal agencies increase the efficiency and effectiveness of infrastructure permitting review and authorisations. This was part of $350 million earmarked for the Permitting Council and $1 billion total for federal agency permitting activities over ten years, as outlined in the IRA.[32] Pipeline capacity has increased dramatically, but at the time of writing the majority of the offshore wind farm pipeline still remains in permitting.

Delays in early projects

Cape Wind

In November 2001, developers proposed the Cape Wind project on Horseshoe Shoal in Nantucket Sound.[33] This would have been the first commercial-scale offshore wind farm in the U.S. The project consisted of 130 wind turbines over almost 65 square km (25 square miles). The farm's maximum electrical output was 468 MW, with an average output of 174 MW, carried to the mainland by underwater cables.

The project faced many challenges, including strong local and political opposition. It also needed federal approval for the turbines and state approval for the cables, which would be on Massachusetts land. Those opposing Cape Wind argued it was too large and unsightly, and would have a negative effect on wildlife, tourism and property values. Opponents also argued higher-priced electricity from the wind farm would raise prices for electricity in the region, while advocates insisted that any increased costs to consumers would be minimal.

The Cape Wind project garnered many opponents including high-profile politicians, and the permits needed for the project took almost a decade after the original proposal. Even after gaining those permits, the project still faced legal challenges from environmental groups, nearby towns and the Wampanoag Tribe. The Cape Wind project was eventually abandoned in late 2017, after 16 years and an estimated spend of over $50 million by the developer, Energy Management, Inc.

Vineyard Wind 1

Located 15 miles off Martha's Vineyard, not far from the abandoned Cape Wind site, the current incarnation of Vineyard Wind is currently under construction. The offshore wind farm development was halted in 2019 under the Trump Administration, but then given the go-ahead in 2021 as part of Biden's push to energise the offshore wind industry. The $4 billion project started to generate electricity in Q1 2024. However, it was not an easy journey to reach this stage. Developers faced numerous regulatory hurdles, local opposition and litigation from the fishing industry.

The Jones Act – which bans the use of American ports to launch foreign construction vessels – was yet another challenge to overcome. Vineyard Wind plans to ship assembled machines to the site on U.S.-flagged barges, which adds extra cost to the project. The eventual success of Vineyard Wind can be attributed to a change in U.S. Administration but also the fact that the farm will be less visible from land, and that developers took local opponents' concerns on board at the start of the project.[34]

Market development vs solar PV and onshore wind, why they differ

Solar PV and onshore wind have much greater installed capacity than offshore wind in the U.S. however offshore wind remains expensive in comparison to onshore wind and solar. This discrepancy is in part due to the shorter development timelines, easier permitting, simpler construction and more developed infrastructure for supply chain and deployment for both solar and onshore wind projects. This is somewhat offset by more consistent generation and higher capacity factors from offshore wind.

Strong growth of the U.S. wind industry in the early 2000s attracted major component manufacturers to establish U.S. facilities. These companies already had the benefit of established supply chains. Consequently, over 85% of wind turbine nacelles are manufactured domestically, with a wider supply chain supporting this industry. Now, with the extension of the Production Tax Credit (PTC) in the IRA, and over a decade of policy support in place, equipment providers are looking to reinvest in their domestic supply chains.[35]

While there are differences between how the two technologies have grown, the offshore wind industry is now in a similar position as the onshore wind industry was two decades ago. Expected growth is attracting equipment providers into exploring investment in new manufacturing plants and, according to the ACP, companies have already announced more than $2 billion in planned investment over the next few years. The IRA's manufacturing PTC and the domestic content bonus for the PTC and ITC could accelerate these investments.[36]

One of the benefits of offshore wind is also its ability to supplement the less consistent onshore and solar PV energy generation. Approximately 70% of current U.S. electricity demand is in coastal states with limited transmission connectivity to areas of land-based wind and solar generation in the centre of the country.[37]

Project pipeline (status, size, participants)

Commercial-scale offshore wind energy deployment is at an early stage in the U.S. As of December 2023, those currently generating power are the small non-commercial Block Island Wind Farm (30 MW) and CVOW Pilot (12 MW). South Fork Wind (132 MW) began generating power in December 2023. Vineyard Wind 1 (800 MW) has started generating power in 2024 and Ocean Wind 1 (1,100 MW) has its permits approved, an offtake agreement and construction is due to start.

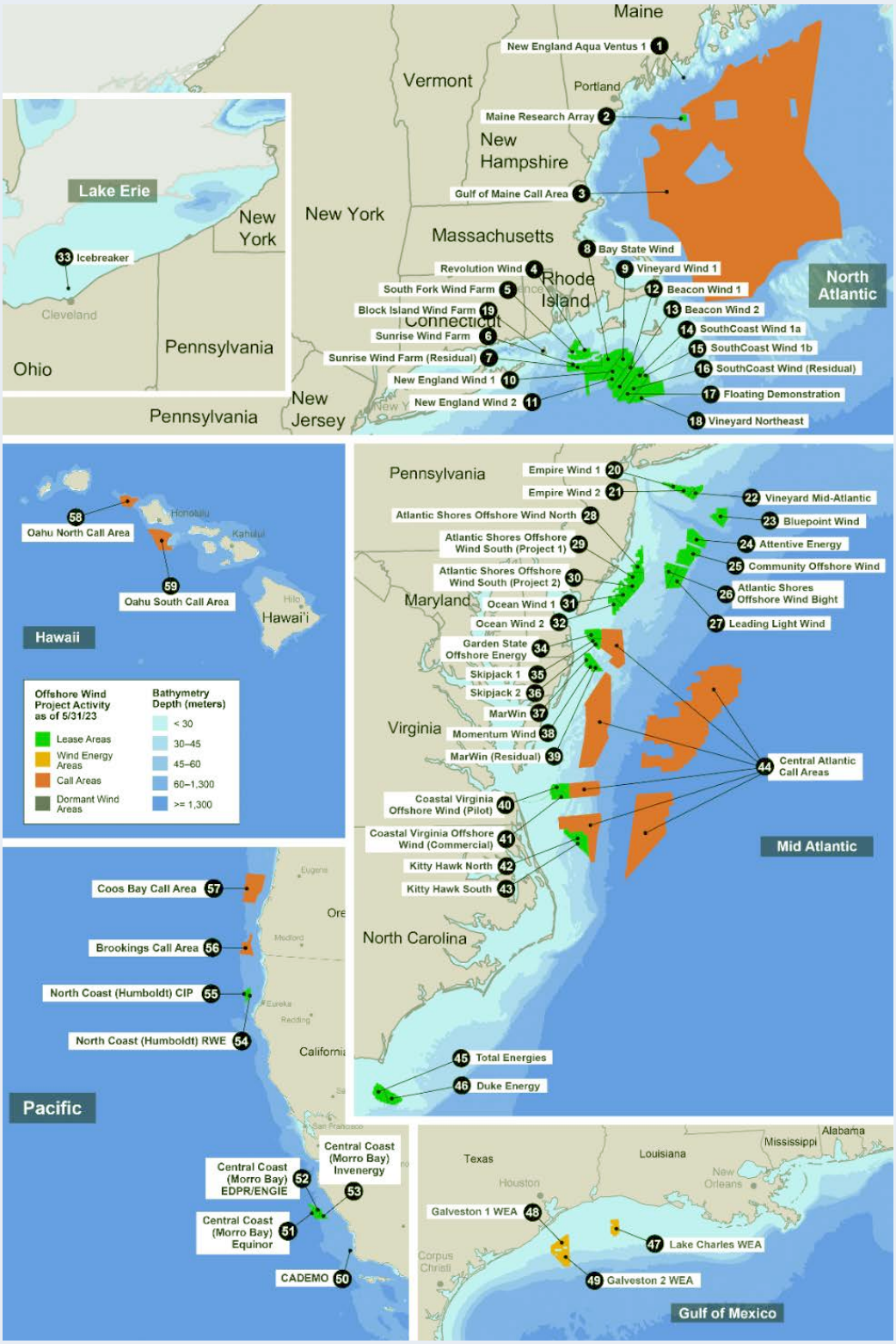
Figure 1: U.S. offshore wind energy pipeline[38]

Status	Description	Total (MW)
Operating	The project is fully operational with all wind turbines generating power to the grid.	42
Under construction	All permitting processes completed. Wind turbines, substructures, and cables are in the process of being installed. Onshore upgrades are underway.	932
Financial close	All permitting processes completed; begins when sponsor announces final investment decision and has signed contracts.	0
Approved	The Bureaus of Ocean Energy Management (BOEM) and other federal agencies reviewed and approved a project's COP. The project has received all necessary state and local permits as well as acquired an interconnection agreement to inject power to the grid.	1,100
Permitting	The developer has site control of a lease area, has received an offtake contract, or submitted a COP to BOEM, and BOEM has published a Notice of Intent to prepare an Environmental Impact Statement on the project's COP. If project development occurs in state waters, permitting is initiated with relevant state agencies.	20,978
Site control	The developer has acquired the right to develop a lease area and has begun surveying the site. If available, developers' announced project capacities are used. If a developer has not announced a specific capacity, it is estimated using a 4-megawatt (MW)/square kilometer (km2) wind turbine density.	24,596
Planning	The rights to a lease area have yet to be auctioned to offshore wind energy developers. Capacity is estimated using a 4-MW/km wind turbine density assumption.	5,039

Source: Department of Energy, 2023 Offshore Wind Market report.

Call Areas[39] in the North Atlantic, Mid Atlantic, Hawaii and off the coast of Oregon are being assessed.

Figure 2: Locations of U.S. offshore wind energy pipeline activity and call areas, May 2023[40]



Source: Department of Energy, 2023 Offshore Wind Market report.

Many of Europe's major developers of offshore wind and other renewables are active in the U.S. market. These include Ørsted, RWE, Equinor Wind U.S., Ocean Winds, CIP and Corio. These companies often partner with a local U.S. utility or a U.S. financial partner. There is a large initial outlay needed to cover lease auction costs and seabed rights even early in development. U.S. solar and onshore developers and retail energy distributors include Avangrid, Eversource, Dominion Energy and U.S. Wind.

State-level procurement targets, supported by federal policy, are likely to remain the prevailing market driver, but ambitious project timelines depend on accelerating the pace of supply chain and infrastructure build-out, regulatory approvals, and sensible offtake agreements to avoid industry delays. While offshore wind projects in the North Atlantic and Mid-Atlantic regions have attracted investment for over a decade, commercial offshore wind leasing is starting to gain traction on the Pacific Coast, the Gulf of Mexico and the Gulf of Maine. Thirteen states have planning goals or procurement mandates for over 100 GW of offshore wind capacity by 2050.[41]

Pipeline, leases and call areas by region; development, opportunities and challenges

North East

The North East is still the initial proving ground for the U.S. offshore wind industry. It has an advantageous combination of strong wind resource, good seabed conditions and huge demand centres. The majority of infrastructure development is happening in this region, mainly due to greater political support. The North Atlantic and Mid-Atlantic is characterized by an abundant wind resource in both shallow (<60 m) and deep (>60 m) waters. The lease areas released up to mid-2022 have all been shallower and suitable for bottom-fixed technologies and are mainly located in the North Atlantic. However, there is the opportunity for floating wind in the future. The Mid-Atlantic pipeline is expected to follow the same pattern.[42]

In September 2023, nine East Coast states and four federal agencies announced an East Coast Memorandum of Understanding (MOU) on Offshore Wind Supply Chain Collaboration to strengthen regional collaboration on offshore wind supply chain development. The MOU will help expand manufacturing facilities, port capabilities and workforce development. The states of Connecticut, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina and Rhode Island will develop sub-regional implementation plans, address supply chain needs for both fixed-bottom and floating offshore wind, and incentivise the development of U.S. offshore wind vessels and U.S. steel production.[43]

Also in September 2023, the DOE and the Department of the Interior (DOI) issued an action plan – part funded by the IRA – to connect the first generation of Atlantic offshore wind projects to the electricity grid and increase transmission over the next several decades. The plan outlines collaboration across jurisdictions on transmission planning, technological development, economic support, siting and permitting.[44]

South East

The South East is the next largest region for offshore wind development, with 12 MW in operation, around 6.3 GW in permitting and 5.3 GW in leased sites[45]. In July 2023, the Bureau of Ocean Energy Management (BOEM) announced three wind energy areas (WEAs) off the shores of Delaware, Maryland and Virginia. The new WEAs total approximately 356,550 acres and have the potential to support 4-8 GW.[46] This region is shallow enough for fixed-bottom systems, but WEAs for floating wind are expected to be leased in the near term.

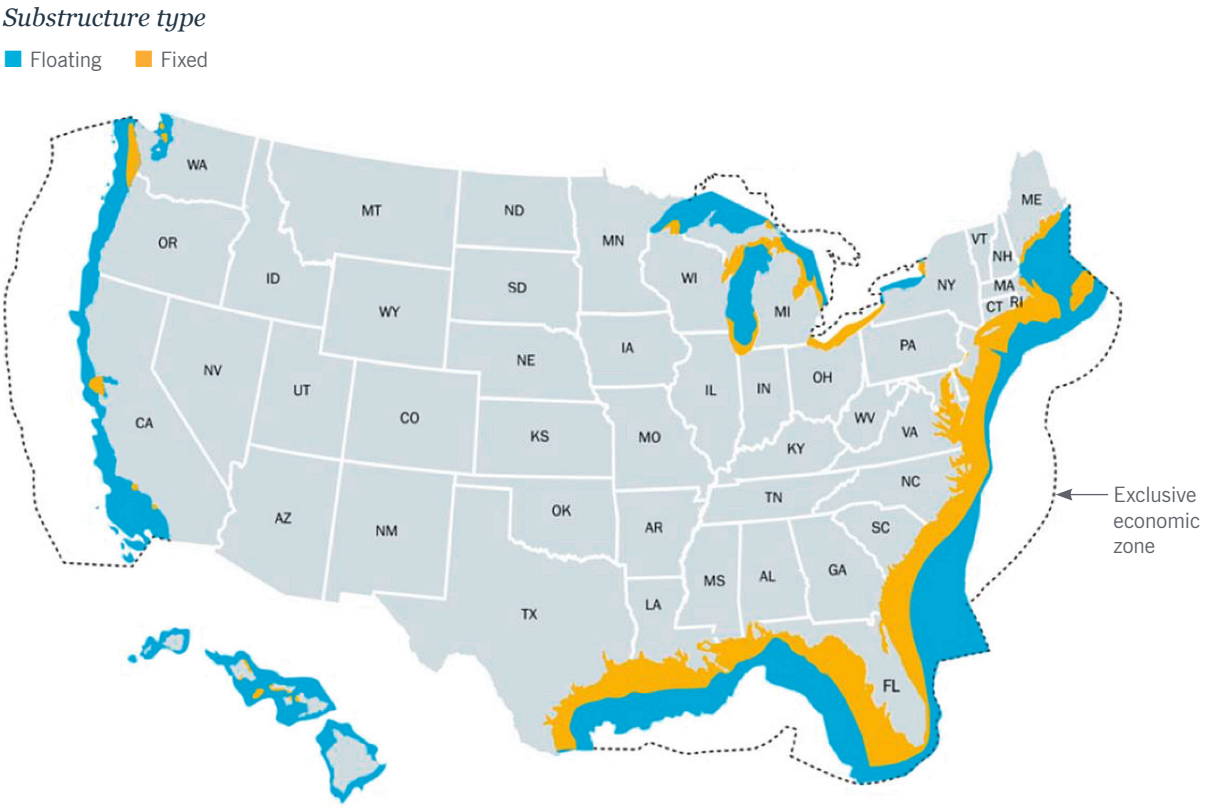
Gulf of Mexico

This region is characterized by an abundant wind resource in both shallow (<60 m) and deep (>60 m) waters, which will need bottom-fixed and floating technologies to develop fully. The region is prone to harsh hurricanes and low soil strength, both of which are critical when considering wind turbine and array design.[47] A recent lease sale for the Gulf of Mexico was undersubscribed. It ended with a single bid from RWE for $5.6M for the Lake Charles Lease Area, 102,480 acres off Louisiana. This was largely due to the abundance of onshore wind in the area.[48]

West Coast, Pacific, Hawaii and Alaska

This region is mainly characterized by very deep waters that will need floating offshore wind. With five WEAs leased in California in 2023 and call areas off Oregon and Hawaii[49] this region is likely to host the first floating offshore wind plants in the U.S. To address deep-water, floating offshore wind challenges, the U.S. FORWARD initiative includes many of the floating-specific activities needed to support environmental, supply chain and transmission development research in this region.[50] The DOE has also proposed a focus on technology development cost reduction and needs surrounding floating platforms and mooring and anchoring systems in deep waters.[51] Projects in this area are likely to qualify for energy communities tax credits. California is leading the charge on offshore wind ambition, with a plan to generate 5 GW by 2030 and 25 GW by 2045.[52]

Figure 3: Offshore wind substructure type by water depth (60m)[53]



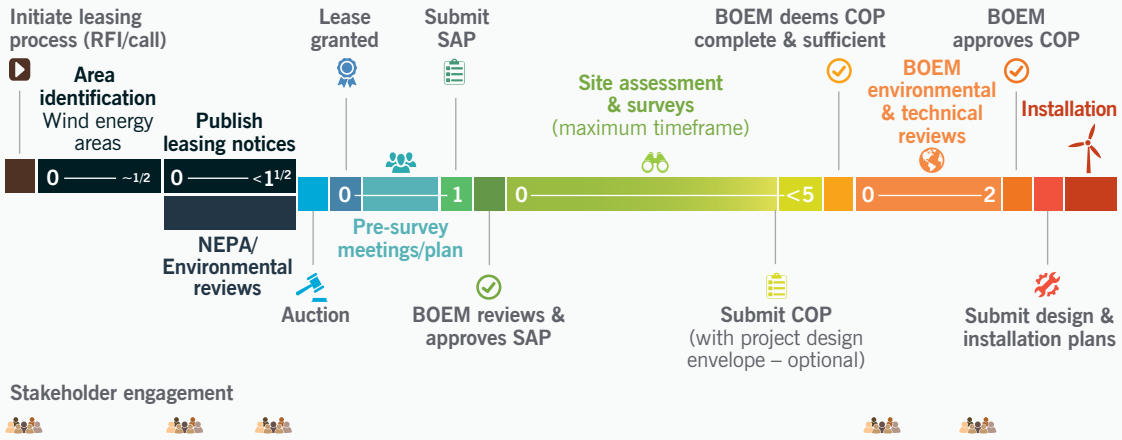
Source: Department of Energy, 2023 Advancing Offshore Wind Energy report.

How does the U.S. differ from Europe?

Permitting regimes

The DOI's Bureau of Ocean Energy Management (BOEM) leads the siting and leasing of offshore wind energy in federal waters and is responsible for all leasing and permitting on the Outer Continental Shelf (OCS), where most offshore wind energy deployment will take place.[54] BOEM applies a four-phase process in the authorization of an offshore wind development: planning and analysis, leasing, site assessment and construction and operation.[55]

Figure 4: BOEM renewable energy process: leasing to operations[56]



Source: Bureau of Ocean Energy Management
SAP: Site Assessment Plan **COP:** Construction and Operations Plan **WEA:** Wind Energy Area

The Bipartisan Permitting Reform Implementation Rule proposed in July 2023 seeks to modernise and accelerate environmental reviews under the National Environmental Policy Act (NEPA) and to encourage early community engagement, so that fewer projects become tangled in litigation.[57] BOEM is working to finalise updates to their permitting regulations, and a final rule on this is expected in March 2024.[58] BOEM plans to develop WEAs in up to seven U.S. regions by 2025 and to hold up to seven new offshore WEA lease auctions including the New York Bight, Carolina Long Bay, Central Atlantic, Gulf of Maine, California, Oregon and the Gulf of Mexico.[59]

The U.S. could learn a lot from countries such as the U.K. and Germany when it comes to permitting.

Germany has a one-stop permitting approach, where a single government authority coordinates the entire process. It also has a fixed permitting timeline, something which could be a great benefit and a relief to developers in the U.S. As Europe's leader in offshore wind, the U.K. is aiming to reduce the permitting process from four years to one, by allowing developers to offset environmental impact on a larger scale, rather than being site-specific.[60]

Despite these bright spots, slow and cumbersome permitting still remains one of the biggest obstacles for the expansion of renewables. Around 80 GW of wind energy projects are stuck in permitting procedures across the continent. The EU has set out to simplify permitting rules by amending the EU Renewable Energy Directive and by putting forward 'emergency measures' allowing governments more leeway to simplify permitting.[61]

Current offtake structures

Developers in the U.S. need to be certain that the current offtake structures – PPAs or offshore renewable energy certificates (ORECs) – will give them adequate compensation for the power generated by an offshore wind farm.[62] Most projects with signed offtake agreements have long-term PPAs with U.S. retail energy distribution companies, while a small number have agreements with utility-owned partners.[63] These can now be bolstered by tax credits from the IRA and tax equity financing structures. Offtakers in some states are now starting to create new contracts that are more flexible and more accommodating to developers.[64]

Europe is in the process of reforming its Electricity Market Design (EMD). This should allow developers to deploy wind energy at scale by leveraging the potential of Contracts for Difference (CfDs) and PPAs, and also ensure that EU wind farms remain attractive to investors.[65]

Supply chains and infrastructure

2022 was a tough year for the wind energy supply chain in Europe, with turbine manufacturers and suppliers suffering from inflation, bottlenecks and poor auction design in some EU countries. The EU's Green Deal Industrial Plan (March 2023) targets the industrial manufacturing of key technologies and equipment in the Net-Zero Industry Act. It sets an annual manufacturing capacity target of 36GW for wind and focuses on simplifying the permitting processes for new factories, identifies strategic dependencies across supply chains and proposes actions to remove existing bottlenecks and increase supply chain resilience. Meanwhile, the Critical Raw Materials Act explores opportunities for mining and processing more raw materials in Europe while forging new trade deals with partners that can diversify supply routes. It also emphasises the importance of recycling and reusing key materials to help increase the resilience of Europe's supply chains.[66]

European offshore wind energy supply chains are more mature than those in the U.S., but the latter is expected to grow and mature, bolstered by significant government support and as more projects begin construction.[67] The IRA extended tax credits to incentivise equipment manufacturers (see 'Incentives' section on p.4) .

New funds made available through the Bipartisan Infrastructure Law and Inflation Reduction Act may help address needs associated with transmission development, port infrastructure (where there are currently large bottlenecks) and supply chain development. Gap analyses can assess supply chain needs unique to floating wind energy, including floating platforms, anchors, mooring lines, and assembly facilities and services.[68]

The Jones Act – which requires service and deployment vessels to be U.S. flagged – is currently a real challenge (see Vineyard Wind 1 on p.7). Some companies are investing in new shipbuilding now, but this is extremely time and capital intensive. However, the Title XI federal ship financing program will boost the domestic shipbuilding industry by providing support for U.S. shipyards to modernize their facilities, build and retrofit vessels, and assist with vessel purchase. The Maritime Administration has also designated offshore wind vessels as Vessels of National Interest.[69]

Cost outlook – *current cost and future declines*

Capex is the single largest contributor to the lifecycle costs of offshore wind power plants and includes all expenditure on equipment, manufacturing, installation and commissioning. These upfront costs usually require over $1 billion for utility-scale projects, and can be several billion for 1GW+ projects.[70] After a period of increasing capex since 2015, the capacity-weighted average capex for offshore wind projects has decreased, with the five-year rolling average (2018-2022) reaching approximately $3,550/kW for projects installed in 2022 globally. The five-year rolling average capex for European and U.S. projects is reported as higher, at just over $4,000/kW.[71] Capex for U.S. projects has been higher in the near term due to the immaturity of supply chains and the U.S. offshore wind market. The total capex to achieve the U.S. national offshore wind target is expected to total around $100 billion by 2030.[72]

The financing rate of a project (weighted-average cost of capital, WACC) has a significant impact on lifetime project costs, as it determines the annual debt service and equity repayment for the initial capex. Recent analysis estimates a WACC of 5.2% for U.S. projects anticipated for commercial operation in the mid-2020s. This is slightly higher than the WACC in established offshore wind markets, such as the U.K. (4%), Germany (3.2%) and Denmark (4.8%).[73] Financing costs and component costs are rising, and for U.S. supply chains this increases the risk of disruption and delays. However, U.S. federal and state government are now working together to create a stronger domestic supply chain that can help de-risk investments in U.S. offshore wind going forward.[74]

There is a trend of escalating lease prices in the offshore wind energy industry, especially in U.S. auctions. The six lease areas in the New York Bight auctioned by BOEM in February 2022 sold for $4.3 billion – with record-setting sales prices far exceeding those of previous BOEM lease area auctions. The average lease price of $728 million ($763/kW) is equivalent to approximately 22% of the average capex of $3,400/kW from U.S. projects. In contrast, the previous 2018 BOEM auction for three leases in the Massachusetts WEA, the lease sale price was around 2% of the total capex. Higher lease prices could result in higher OREC pricing.[75]

There is typically a strong correlation between high sale prices and a wind lease area's proximity to states with aggressive procurement goals and contracted offtake mechanisms. State policies give developers more certainty over demand for an offshore wind project's power, and adequate compensation via a PPA or an OREC. The absence of a robust state offshore wind policy may have reduced final lease prices in the Carolina Long Bay auction (May 2022), where lease areas of a similar size to those in the New York Bight auction (February 2022) attracted lower bids. Reduced wind speeds and limited port, supply chain and grid infrastructure, as well as greater hurricane risk, may also have contributed to lower bids.[76]

The West Coast and much of the remaining North East and mid-Atlantic sites require floating offshore wind (FOW), which is currently more expensive because of the complexity and novelty of the technology. The Floating Offshore Wind Shot, led by the DOE and DOI, is an initiative to drive the design, development and manufacturing of FOW. The initiative aims to reduce the cost of FOW energy by more than 70%, to $45 per MW-hour by 2035 for deep water sites far from shore. Around two-thirds of U.S. offshore wind energy potential exists over waters too deep for current fixed-bottom wind turbine foundations and so need floating platforms.[77]

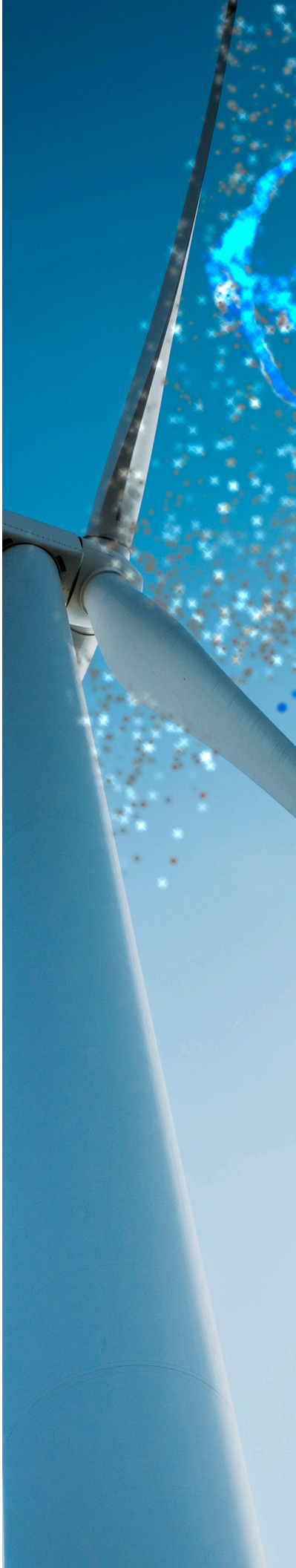
Looking to the future, there should be a decline in costs: proposed rules to speed up permitting timelines, an expected decrease in component costs and infrastructure development supported by government should lead to a lower cost of capital in a more developed market. State and federal tax credits also provide much-needed incentives to help with the cost of developing wind farms (see 'Incentives' section on p.4) .

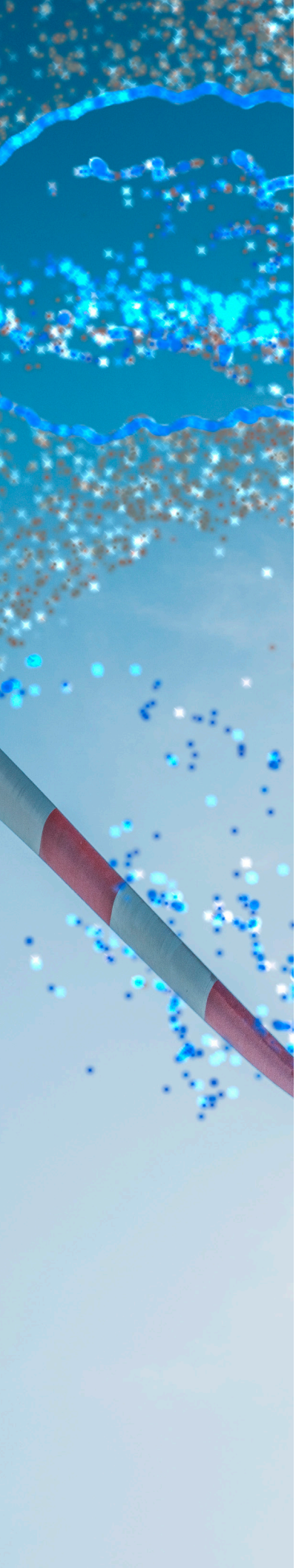
Synergies with green hydrogen and other energy transition areas

Offshore wind-to-hydrogen systems can optimize the use of offshore infrastructure, especially if hydrogen electrolysis is co-located offshore with wind energy generation. Several projects have already been proposed or built in Europe, and the IRA provides a pathway to cost-competitive wind-hydrogen systems in the U.S. in the near future.[78] Hydrogen can help store excess energy generated by offshore wind, by converting it into hydrogen. This can be converted back into electricity by fuel cells or hydrogen-driven turbines when needed.[79]

As it is currently expensive to produce, hydrogen from renewables (green hydrogen) accounts for less than 1% of annual hydrogen production. In June 2021, the DOE announced the Hydrogen Shot, an initiative aiming to reduce the cost of clean hydrogen by 80% to $1 per 1 kilogram in 1 decade.[80] In 2022, the IRA extended the PTC to hydrogen with credit based on the emissions intensity of hydrogen production. This is expected to drive growth, with the IEA estimating federal support for low-carbon hydrogen to drive 4 GW/ 1.5% of total renewable capacity 2022-27.[81] In August 2023, the DOE announced the award of nearly $34 million to 19 industry- and university-led research projects to advance cutting-edge technology solutions. The US Department of Energy's Office of Fossil Energy and Carbon Management (FECM) has also announced investments of more than $122 million in 72 projects since January 2021. These will explore new, clean methods to produce hydrogen and how to improve the performance of hydrogen-fuelled turbines.[82]

The TRANSFORM initiative aims to advance offshore wind co-generation technologies, also known as wind-to-X technologies, which use offshore wind energy to produce another energy solution, such as hydrogen co-generation.[83] Storage to optimize the variability of renewables now qualifies for the ITC under the IRA and according to consultancy Wood Mackenzie, incentives under the IRA will cut the cost of solar, wind and storage equipment by anywhere from 20% to 60%.[84]





Commentary on recent delays and cancellations of projects

U.S. offshore wind ambitions are threatened by recent project cancellations and developers are facing difficult decisions regarding some projects in the North East. Initial economic models for these projects have broken down from a combination of rising capex and financing costs, and falling or fixed offtake prices. In a substantial blow to Biden's target of 30 GW offshore wind by 2030, Ørsted – the world's largest offshore wind farm developer – has cancelled two large offshore windfarm projects in the U.S. (Ocean Wind 1 and Ocean Wind 2) at a cost of more than £3 billion. The company cites surging costs facing the global wind industry, caused by high inflation, soaring interest rates, the rising cost of building supplies and supply chain bottlenecks. Additionally, two projects being developed by a JV of Corio and Total were cancelled after major economic shifts in the business plan. This was in part driven by GE Vernova cancelling a new New York-based manufacturing facility which was going to supply blades to the wind farms.

Meanwhile, BP also announced a write-down on two wind projects off the coast of New York. It is not only unexpected costs, but delays caused by permitting timelines, which are not keeping pace with the rapid growth in offshore wind.[85] Norway's Equinor and its partner BP are seeking a 54% price increase for the power produced at three planned offshore US wind farms, while Ørsted is also seeking more US tax credits for projects.[86]

Ørsted's project cancellations follow a series of wind farm cancellations and delays on the East Coast. Despite federal subsidies, it seems that the offshore wind sector is still finding its footing and at least 10 East Coast projects have recently tried to renegotiate offtake prices.[87] Avangrid, a subsidiary of Spanish utility company Iberdrola, reportedly abandoned a joint venture with the utility Eversource Energy in October 2023 and scrapped its offshore wind project off the coast of New England. Consequently, S&P Global Commodity Insights is expected to lower its previous prediction that U.S. offshore wind capacity would reach 22GW by 2030, making Biden's offshore wind target appear unobtainable. However, the largest planned offshore wind installation in the U.S. is still set to go ahead: Dominion Energy's 2.6 GW Coastal Virginia offshore wind project has been approved and is on track to be completed in 2026.[88]

In October 2023, Ørsted warned that the New York State Public Service Commission's rejection of petitions to increase prices on previously agreed PPAs has put their 924MW Sunrise Wind project at risk.[89] These projects will need to strike a balance between more aggressive cost reductions and finding more lucrative PPA contracts to improve profit margins and put the offshore wind farm pipeline back on track.

Project case studies

SOUTH FORK WIND

In December 2023 Ørsted and Eversource celebrated the first electricity generated by South Fork Wind, 35 miles (56 kilometers) east of Montauk Point, New York. So far, two 11 MW turbines have been installed. Once the other planned 10 turbines are spinning, the wind farm will be able to generate 132 MW of offshore wind energy to power more than 70,000 homes. This is the first step towards New York's target to transition to a carbon-free electricity system by 2040, and the state's aim to install 9 GW of offshore wind by 2035.[90]

VINEYARD WIND 1

Vineyard Wind 1 (Avangrid and Copenhagen Infrastructure Partners) will be a 62-turbine wind farm, 15 miles (24 km) off the coast of Massachusetts. As of February 2024, the wind farm began delivering full power from five turbines to the New England grid, enough to power 30,000 Massachusetts homes.[91] Over the coming months, 62 turbines, each up to 850 feet high with blades 350 feet long, will be installed, and an estimated output of 800 MW, to power around 400,000 homes.

REVOLUTION WIND

Offshore construction on the first utility-scale offshore wind farm for Rhode Island and Connecticut is due to start in 2024, as Revolution Wind has received approval of the project's COP from BOEM. This project, powered by Ørsted and Eversource, will provide 400 MW of clean, affordable offshore wind power to Rhode Island and 304 MW to Connecticut. This equates to powering around 400,000 homes.[92] Critical to approval was the work done by Ørsted and Eversource to reach provisions and protections for marine habitats and species by working closely with a range of external organisations. The companies also worked closely with the States of Connecticut and Rhode Island on the development of infrastructure, jobs and economic growth for the region.[93]

Stronger winds ahead

Despite the current obstacles of slow permitting and rising costs, the future for the U.S. offshore wind industry is picking up pace. While the nascent U.S. industry may seem far behind that of Europe and APAC, the Biden Administration has taken great strides forward with ambitious offshore wind targets, as well as several initiatives and incentives which should encourage private sector investment and streamline the development process for offshore wind farms of the future. The target of 30 GW by 2030 has pushed the federal government to work with state governments to propel offshore wind.[94] Slowly but surely, the industry is also building up strong supply chains and sound infrastructure. The signs are positive and point to one overall conclusion: the offshore wind industry will be a central component of the U.S.' clean energy future.

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