OFFSHORE WIND FACTS

THE ECONOMICS OF OFFSHORE WIND

What you should know:

- The cost of offshore wind fell by over 67% globally, from 2012 to 2020, as the industry scaled up and technology improved.
- Post-2020, economic shocks from the COVID-19 global pandemic and Russia's invasion of Ukraine have driven rapid inflation, adding significantly to the cost to build offshore wind and other types of energy and infrastructure projects.
- Increases in fossil fuel prices are a major driver of inflation. This has increased the cost of electricity produced by burning fossil fuels. Since renewable energy projects such as offshore wind offer stable, long-term pricing, accelerating the energy transition away from fossil fuels will reduce the economy-wide impact of fuel price spikes in the future.
- The U.S. recently enacted new policies to reduce the cost of offshore wind and attract domestic manufacturing investments. Under these new policies, projects can be eligible for up to a 50% credit against the cost to build a qualifying offshore wind farm. Domestically produced offshore wind turbine components can receive up to $16 million in additional incentives per turbine.
- The National Renewable Energy Laboratory (NREL) estimates that offshore wind will create tens of thousands of new jobs every year and contribute over $1 billion annually in Gross Domestic Product (GDP).

The Cost of Offshore Wind

Global Trends

The cost of offshore wind technology fell substantially over the past 30 years thanks to the commercial benefits of scale, driven by decarbonization goals in Europe. As European countries have installed ever-larger volumes of offshore wind turbines, the levelized cost of energy (LCOE) has fallen. For example, offshore wind project developers in the United Kingdom signed contracts to sell their energy at an average price of $143 USD per megawatt hour (MWh) in 2010, when only a little more than 500 megawatts (MWs) of offshore wind turbines were operational. By 2019, U.K. project developers were signing contracts on average worth $50/MWh, by which time installed capacity in the U.K. had reached nearly 10,000 MWs. Globally, the average LCOE of offshore wind fell from a 2012 high of $255/MWh to only $84/MWh in 2020, a reduction of 67.5% (Lee & Zhao, 2020).

An important driver of cost reductions in this timeframe was a change in the size and capacity factor of offshore wind turbine technology. The average offshore wind turbine installed in 2010 was rated for 3 MW of electricity generation with a rotor diameter of 90 meters. In 2021, the average diameter of an offshore wind turbine rotor had reached 220 meters, with a rated output of 12 MW, and up to 16 MW offshore wind turbines proposed for more recent projects. Larger turbines produce more energy using fewer turbines, which reduces the up-front cost of installation as well as the cost of operations and maintenance over time. The capacity factor, defined as the percentage of actual energy produced from what could be produced if winds blew at full speed all the time, also increased from 38% to 50% - 60% over the same

time frame. This is an important distinction between offshore wind and other forms of renewable energy, which are generating electricity for fewer hours every year. The average capacity factor for solar energy projects globally in 2018 was just 14% (Donovan et al., 2019). This means that a 100 MW solar project would produce 14 MW on average, while a 100 MW offshore wind project would produce 50 MW on average.

U.S. Offshore Wind Prices and Impacts of Inflation

The U.S. is in the early stages of scaling up a domestic offshore wind industry. As of May 31, 2023, 27 U.S. projects had signed Power Purchase Agreements (PPAs) or Offshore Renewable Energy Credit (OREC) deals, representing a total capacity of 17,567 MWs of offshore wind generating capacity, although only 42 MWs of projects had become operational by that date. The weighted average of utility-scale (greater than 100 MW) offshore wind contracts signed in the U.S. from 2017 to 2021 was $83/MWh, with a downward trend over time. However, widespread inflation and supply chain shocks are challenging the economic viability of these projects. In inflation-adjusted terms, the weighted average value of these contracts would be closer to $93/MWh in 2023 dollars (Musial et al, 2023), but most contracts do not include adjustment mechanisms to account for inflation.

By BloombergNEF's calculation (Figure 1), rising interest rates have added $27.20/MWh to the LCOE of these projects and increases in supply chain costs add another $16.90/MWh (Jain, 2023). Even with an increase in federal tax credits, the expected LCOE for offshore wind projects in the U.S. has risen from $77.30 in 2021 to $114.20 in 2023 (Jain, 2023). Indeed, in early 2024, New Jersey and New York awarded projects at or near $150/MWh, representing a right-sizing of offshore wind contracts to meet the demands of rising costs and interest rates.

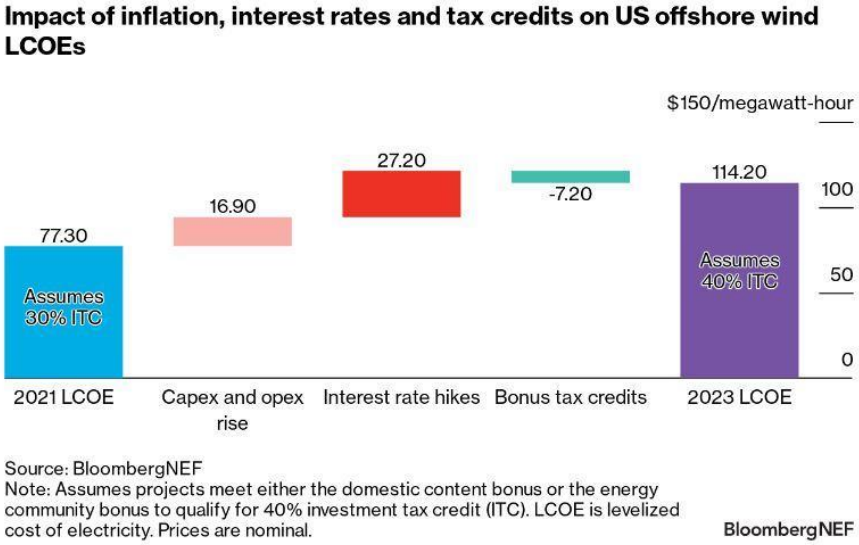

Figure 1 BloombergNEF. (Jain, 2023).

Increased costs of this magnitude, after electricity contracts are signed, can make a project uneconomic and developers may not be able to secure the financing to build the wind farm. Because of these factors, offshore wind project developers in Massachusetts, Connecticut, New York, New Jersey, and Maryland have chosen to cancel their existing contracts and, in some cases, plan to re-bid the projects in future offshore wind procurement solicitations (The Business Network for Offshore Wind, 2023). For example,

4.3 gigawatts (GW) of offshore wind projects were at risk of cancellation after the New York Public Service Commission (NY PSC) declined to award contract price adjustments that offshore wind developers had requested. In the same decision, the NY PSC also declined to award contract price adjustments to roughly 90 onshore wind and solar projects that had requested contract price adjustments, in favor of maintaining the integrity of competitive procurement processes (Christian, 2023). As a follow up, the New York State Energy and Research Authority (NYSERDA) released a solicitation to allow projects to re-bid and, indeed, two offshore wind projects who terminated their existing contracts with NYSERDA (Empire Wind and Sunrise Wind) received awards and proceeding with their development processes.

In 2023, all forms of infrastructure and energy resources experienced increases in cost due to inflation, interest rates, supply chain disruptions, and global conflicts. According to an analysis by Energy Innovation, “the same near-term trends driving inflation in the wind and solar industries are largely present in other industries, including fossil fuel extraction and infrastructure construction” (O’Boyle et al., 2023). Russia’s invasion of Ukraine caused global fossil fuel prices to spike, and the global manufacturing sector that produces raw materials and offshore wind equipment is still largely reliant on fossil fuel energy. Also, fossil fuel generators have had to raise their electric prices; this doesn’t cause a problem in that sector because fossil fuel contracts are typically shorter term or allow the generator to pass higher costs on to the electricity consumer, which renewable electricity contracts typically do not have. Plus, these fossil fuel projects are already built so do not need to manage higher constructions costs related to inflation like new, offshore wind projects do. Accelerating the energy transition away from fossil fuels will reduce the economy-wide inflationary impact of fuel price spikes in the future.

Tax Credits and Subsidies

Various federal tax credits and incentive programs have been enacted to help reduce the cost of electricity generated by offshore wind and other renewable energy resources. These credits were extended and modified in 2022 when Congress passed the Inflation Reduction Act (IRA), which streamlined credits for future projects by eliminating technology-specific distinctions. Developers of qualifying new renewable energy generating facilities will have the option to receive a Production Tax Credit (PTC) for electricity generated in the first ten years of production, or an Investment Tax Credit (ITC) to rebate a portion of the up-front capital costs to build the project. The credits are administered in a tiered system where most of the credit value is associated with a requirement to pay prevailing wages and support registered apprenticeship programs. Bonus credits are also available to developers who meet domestic content criteria or who build their projects in energy communities (areas that have experienced coal closures, have high rates of fossil fuel employment, or are experiencing other economic or environmental challenges). Per the U.S. Department of Energy (DOE), an offshore wind project that meets the requirements for these tax credits and all possible bonus credits can receive a credit of up to 50% of the total capital cost to build the wind farm.

The IRA also includes support for the manufacturers of offshore wind and other renewable energy components. In addition to tax credits available on a competitive basis to help offset the cost of building new manufacturing facilities, manufacturers of qualified components will also be eligible to receive tax credits for every component produced in the U.S. For offshore wind components, this includes blades, nacelles, towers, and foundations. A 10% credit is also available for the fabrication of offshore wind vessels. The manufacturing production credits scale based on the energy generation potential of the component, known as total rated capacity. For example, a qualifying U.S. produced offshore wind nacelle with a total rated capacity of 15 megawatts (MW) would receive a tax credit for $750,000, a blade for the same turbine would receive $300,000, the tower would receive $450,000, and a fixed-platform foundation would receive $300,000. Bringing the total potential tax credits for an entirely U.S. fabricated 15 MW offshore wind turbine to $2.4 million (U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy [DOE EERE], 2023).

The tax credits created and modified by the IRA require detailed guidance to determine the specific eligibility criteria and clearly define terms. The Internal Revenue Service (IRS) is in the process of issuing this guidance so that developers and manufacturers can plan their investments accordingly.

Renewable energy resources are not alone in receiving support from federal and state subsidies. Fossil fuel resources are heavily subsidized in the U.S. as well as abroad, although unlike renewable energy subsidies that expire, most U.S. subsidies for fossil fuels are permanently incorporated into the tax code. A 2019 analysis conservatively pegged subsidies for fossil fuels at roughly $20 billion per year, nearly $25 billion in 2023 dollars (Laporte, 2019). Globally, the International Monetary Fund (IMF) identified more than $7 trillion in fossil fuel subsidies in 2022 (Figure 2), a figure that has grown more than 75% since 2015 (Black et al., 2023).

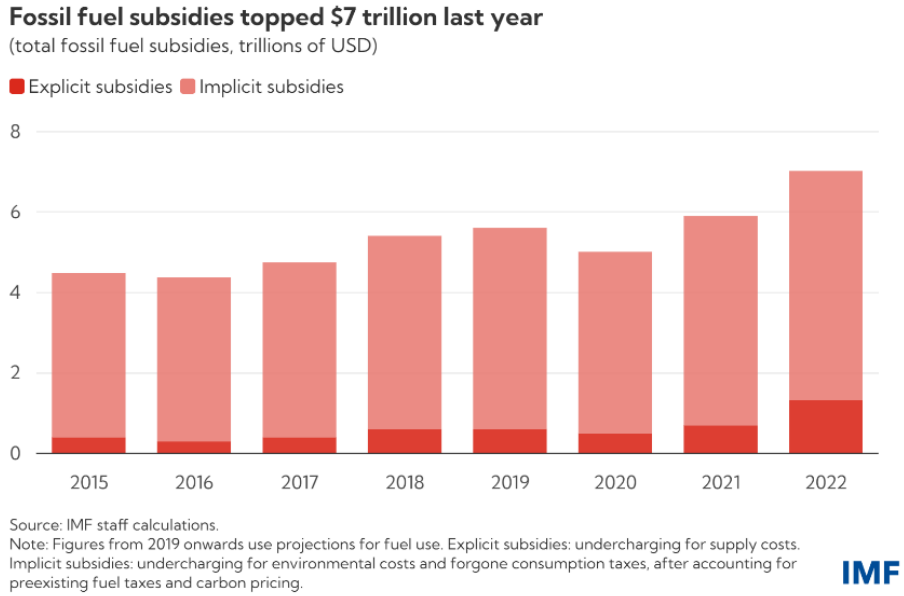

Figure 2. (Black et al., 2023).

Economic Benefits of Offshore Wind

Offshore wind is poised to deliver numerous economic benefits to local communities and the broader U.S. economy, with the potential to grow significantly as manufacturing tax credits stimulate further investment and new bidding credit mechanisms bring additional revenue to local communities. The Bureau of Ocean Energy Management (BOEM) leases areas on behalf of the U.S. federal government for offshore wind energy development on the Outer Continental Shelf (OCS) in an auction format that awards sites to the highest bidder. In 2022, BOEM conducted its first lease area auctions in California using a new bidding credit structure, which allows developers to allocate a portion of their total bid to local investments and other programs (Bureau of Ocean Energy Management [BOEM], n.d.). This strategy will redirect some of the revenues that would otherwise flow to the U.S. Treasury directly to the benefit of communities that will be impacted by offshore wind development. Auctions conducted prior to December 2022 did not include bidding credits or other revenue sharing mechanisms, meaning that the $4.37 billion collective winning bids for the New York Bight auction in early 2022 will flow entirely to the U.S. Treasury (U.S. Department of Interior [DOI], 2022). A group of Northeastern state governors sent a letter to the Biden Administration

urging action to establish a more robust revenue sharing mechanism that would direct more lease area auction revenues to the states supporting offshore wind development, a change that would require Congressional approval (Lamont et al., 2023).

Offshore wind development, construction, operations, and associated manufacturing activities are expected to support tens of thousands of new jobs every year in the pursuit of the Biden Administration's goal to install 30 GWs of offshore wind by 2030. National Renewable Energy Lab's (NREL) 2022 workforce report identifies a wide range of employment estimates, from 15,000-58,000 Full Time Equivalents (FTEs) per year based on varying levels of domestic manufacturing (Figure 3) (Stefek et al., 2022). Their domestic offshore wind supply chain report from the same year estimates that domestic production of offshore wind components can deliver $1.6 - $6.2 billion in value-added GDP growth to the U.S. economy per year (Shields et al., 2022).

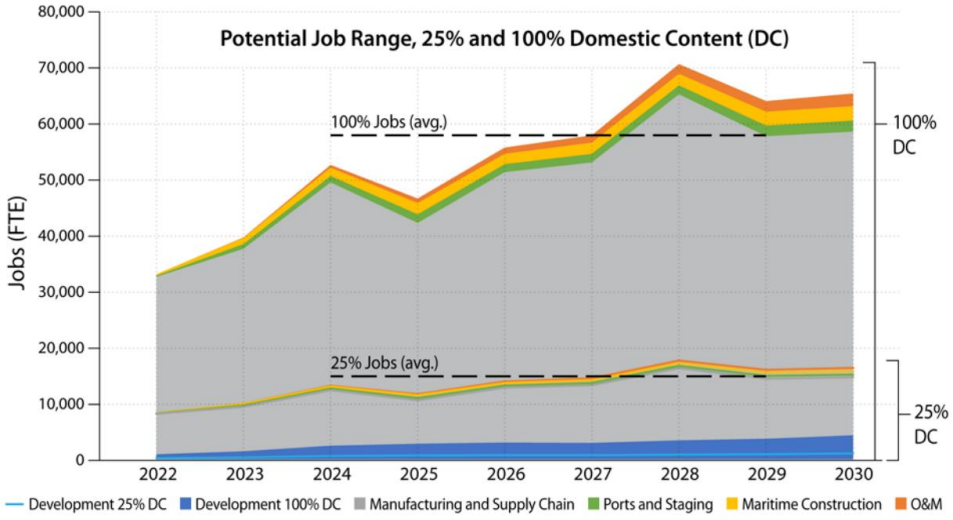

Figure ES-2. Potential job estimates across industry segments to support a project pipeline of 30 gigawatts of offshore wind energy by 2030, assuming a domestic workforce lower bound of 25% and an upper bound of 100%. Also shows a range of average employment each year between 2024 and 2030.

Figure 3. (Stefek et al., 2022).

One of the most important economic benefits that offshore wind provides is related to its energy system value. Transmission system operators plan and manage the movement of electricity to serve customer needs. Variable renewable energy resources generate energy at different times, and a diverse portfolio of different energy generation types allow transmission system operators to meet energy needs dynamically and over large areas. Offshore wind's proximity to coastal areas of high population concentration reduces the need for long-distance transmission lines to deliver onshore renewables from distant areas to these load centers. Offshore wind delivers additional benefits to the energy system in the form of its capacity factor (how often it generates electricity) and its resource profile (the time of day and year when it generates the most energy). Offshore wind operates at a much higher capacity factor than other forms of renewable energy, and in most areas, generates more power during evening hours and winter months when energy demand is high, but solar energy resources are more limited. Wind energy also provides certain benefits to the physical needs of electricity grid management that are difficult to replicate with solar and battery storage. These characteristics mean that a regional grid with offshore wind resources will require fewer "peaker plants" (expensive fossil fuel electricity generators that only operate during periods of very high energy demand). Reducing the use of these peaker plants and other fossil fuel plants, protects ratepayers from higher, more variable electricity costs and avoids negative public health

outcomes like asthma and other respiratory diseases from fossil fuel combustion (Mills et al., 2018). The Reinvesting in the Shoreline Economies and Ecosystems (RISEE) Act

If enacted, the RISEE Act would establish several dedicated streams of funding for coastal infrastructure and resiliency to support and protect coastal communities that could be most impacted by climate change. Read the text of the bill here.

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