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# Japan offshore wind: The ideal moment to build a vibrant industry

As construction starts on Japan's first large commercial offshore wind farm in the coastal waters of Akita, the country is heralding a future of energy independence.

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**With the passage** in late 2019 of a law that allows offshore turbines to operate for 30 years, Japan has begun in earnest its journey away from fossil fuels and nuclear energy.

The two wind farms of the ¥100 billion Akita project will generate with a capacity of 140 MW, enough electricity to power at least 150,000 of Japan's 52 million homes. By 2030 Japan plans to have installed a total of 10 GW, and the country's possibilities are even greater. The International Energy Agency estimates Japan has enough technical potential to satisfy its entire power needs nine times over.[1]

Japan can take advantage of the technology advances and cost improvements the offshore wind industry has made since its early days in Denmark in the 1990s. Today, it can learn from the experiences of other countries, not only in creating the turbines and wind farms but also in building markets, setting offtake prices, and designing regulation and financial incentives.

In only a handful of decades, offshore wind has become one of the core power-generation technologies of Europe, with installed capacity of 22 GW[2] and about 100 GW planned by 2030.[3] Taiwan and the United States have already commissioned the first small projects and plan for more than 10 and 25 GW by 2030, respectively.[4] During the industry's 30-year evolution, costs have fallen so sharply that offshore wind now compares favorably with competing energy sources.

But that does not mean Japan's journey will be simple. It will require multiple players, including regulators, utilities, and investors, to do their part in a country where the public remains skeptical about offshore wind's cost competitiveness with other power sources. Japan has the additional challenge of needing floating platforms for a majority of the sites because of its deep coastal waters as well as turbines that can withstand earthquakes and typhoons and make use of low wind speeds.

All these challenges are surmountable, and some of them offer Japan the opportunity to become a leader in developing new technology. The country is on the cusp of joining the global offshore wind scale-up club at the most opportune time in the industry's history.

In this article, we lay out the benefits of offshore wind for Japan; the lessons Japan can draw from Europe, Taiwan, and the United States; and the five critical steps to harnessing the opportunities and overcoming the hurdles it will face.

## Benefits and opportunities

There are key benefits and opportunities for Japan to seize as it moves into offshore wind. They range from the chance to forge an entirely new export industry to shaking off the country's dependence on foreign and carbon-intensive energy sources. This is because offshore wind achieves five objectives.

1. It offers a better alternative to fossil fuels and nuclear power than onshore wind and solar, both of which are constrained by lack of available space, poorer base-load characteristics,[5] and NIMBYism.[6] The move away from coal is particularly important to Japan, given the government's environmental and decarbonization targets. Meanwhile, the need to find an alternative to nuclear power has intensified because of the public's waning trust in Japan's aging reactors following the meltdown at Fukushima in 2011.

[1] "Offshore wind outlook 2019," IEA, November 2019, iea.org.
[2] As of Q2 2020 (June 08, 2020).
[3] Only capacity installed or foundation installation underway.
[4] As of Q2 2020 (June 08, 2020).
[5] Baseload power is the minimum amount of electric power needed to be supplied to the electrical grid at any given time.
[6] NIMBY is an acronym for "not in my backyard."

2. It increases security of supply and decreases the resource-poor country's reliance on foreign sources of energy. Japan has the lowest self-sufficiency rate among the OECD's ten largest member nations (Exhibit 1).

3. It reduces Japan's fuel bill. A 1 GW offshore wind farm cuts the country's annual fuel import bill by more than $300 million.[7] As the industry matures and costs fall below that of alternatives, it will reduce Japan's total energy bill, which is still heavily dominated by liquefied natural gas (LNG), coal, and nuclear power.

4. It supports local industry, infrastructure, and job creation, often in disadvantaged regions. This is especially attractive given the economic downturn caused by Covid-19. In Europe, for example, the industry association estimates that almost 290,000 people work in wind energy (Exhibit 2) and expects that number to rise to 570,000 by 2030.[8]

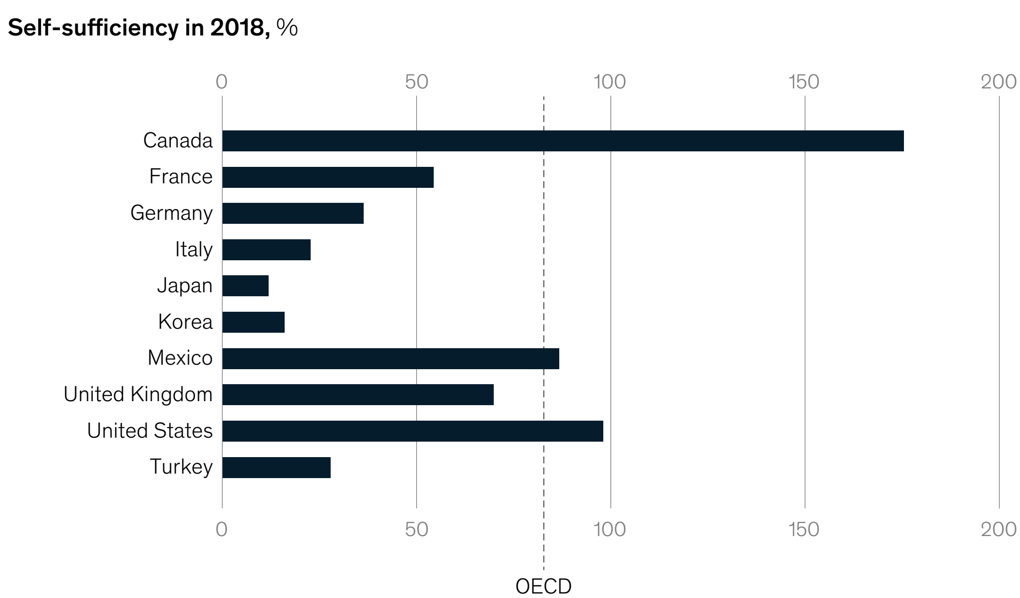
5. It offers Japanese companies the chance to become international leaders in the design and construction of technologies that address some of the island's challenges. These technologies include floating foundations and turbines that can withstand typhoons, tsunamis, and earthquakes, as well as those that can operate efficiently at low wind speeds. These new technologies can be installed at home and exported to countries with similar conditions to Japan, such as China, South Korea, and the Philippines.

## Lessons from Europe, Taiwan, and the East Coast of the United States

The offshore wind industry has made great strides over the past three decades as it spread around the globe. Taiwan and states along the northeast coast of the United States provide particularly apt examples of how to successfully adopt technology advances and learn from the lessons of

Exhibit 1

### The self-sufficiency rate for the ten largest OECD countries in 2018.



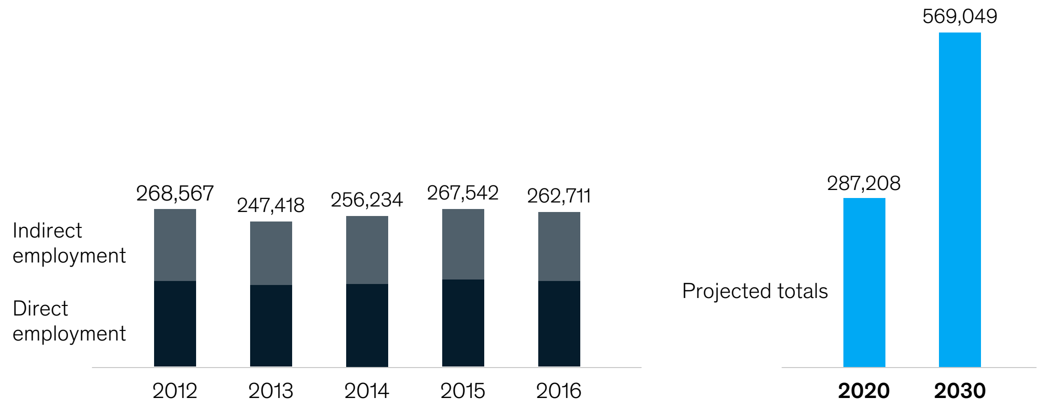

Source: World Energy Balance Overview 2019

[7] "Offshore wind outlook 2019," IEA, November 2019, iea.org.
[8] "Local impact global leadership," WindEurope, windeurope.org.

Exhibit 2

## The number of direct and indirect jobs created in the European Wind industry (onshore and offshore), as specified by full-time employees.

**Jobs generated by Europe's wind energy industry**




Source: WindEurope

early European experiences. From 2010 to 2019, the global weighted average levelized cost of electricity (LCOE)[9] from renewables decreased by 30 to 80 percent. Today, all technologies are in the range of cost competitiveness with fossil-power generation.

**Europe (from the first decade in 2000)**

Following Denmark's adoption of offshore wind energy in the early 1990s, European offshore wind took off in the first decade of the 2000s. The United Kingdom and Germany developed markets for offshore wind energy through strong government support and subsidies. Initial projects were complex and comprehensive in scope. Transmission system operators (TSOs) or developers were responsible for connecting offshore facilities to the onshore grid they operated. Large subsidies kick-started the development of local content and the infrastructure that was needed to get the industry off the ground. Over time, governments were able to reduce their involvement. Auctions were introduced to drive down costs, which led to an industry that is now largely cost-competitive against other sources, such as natural gas.

**Taiwan (from 2016)**

Taiwan built on Europe's experience. A generous initial feed-in tariff scheme supported the building of local infrastructure, while Taipei's commitment to adequate future volume allowed for cost reductions. By the second phase, Taiwan was able to graduate to a more competitive bidding process. Between the initial feed-in-tariff and the tender, prices fell by almost 60 percent[10] (Exhibit 3). This allowed the government to renegotiate the terms of the first project.

**East Coast of the United States (from 2016)**

On the US East Coast, states such as Rhode Island and Massachusetts leap-frogged the initial stages of Europe and Taiwan. Support schemes were introduced only for a small number of initial demonstration projects while the main

[9] IRENA Power Generation Costs 2019; weighted average from plants commissioned in 2010 and 2019, LCOE calculation with a WACC of 7.5 percent for OECD countries and China and 10 percent for the rest of the world.
[10] Press (e.g. Recharge News).

projects were directly auctioned in a competitive bidding process. Massachusetts, for example, has already achieved low prices for its first large project: In 2018 the state awarded Vineyard Wind a contract for an 800 MW wind farm at a price of $65 per MWh. In 2019, the 804 MW Mayflower wind farm even achieved $58 per MWh, 76 percent less than Rhode Island paid in its contract for the Block Island Wind Farm nine years earlier.

## Harnessing the opportunities and overcoming the hurdles

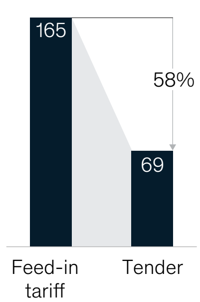
Five factors are critical to establishing Japan's offshore wind industry and the supply network that supports it.

1. *Cost competitiveness.* Japan needs to forge a path toward cost competitiveness with established energy sources (see sidebar "Cost-reduction opportunities along the value chain").

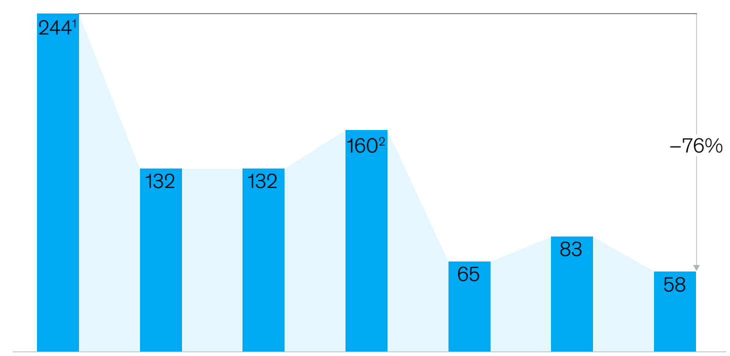
Exhibit 3

### Recent offshore wind tenders in the United States and Taiwan achieved cost reductions of 60 to 80 percent compared to initial projects.

**Prices in Taiwan,** €/MWh (at fx rates on Aug 8, 2018)




**Prices in the US,** $/MWh




| **Project** | Block Island Wind Farm | MarWin | Skipjack | South Fork | Vineyard Wind–phase 1 | Sunrise Wind/ Empire Wind | Mayflower |
|---|---|---|---|---|---|---|---|
| **State** | Rhode Island | Maryland | Delaware | New York | Massa-chusetts | Rhode Island/ New York | Massa-chusetts |
| **Capacity,** MW | 30 | 248 | 120 | 96 | 800 | 880/816 | 804 |
| **COD**[3] | 2016 | 2023 | 2023 | 2022 | 2023 | 2024 | 2024 |
| **Developer** | Deepwater Wind/ Ørsted | US Wind | Deepwater Wind/ Ørsted | Deepwater Wind/ Ørsted | Vineyard Wind | Equinor, Eversource/ Ørsted | Shell, EDP/ ENGIE |

[1]Remuneration increases by 3.5 percent annually to $479/MWh by year 20.
[2]Estimated.
[3]Announced commercial operation date.
Source: US Department of Energy; 4C Offshore; McKinsey analysis

## Cost-reduction opportunities along the value chain

**For its first 20 years,** offshore wind was more expensive than alternative energy sources such as onshore wind and solar. Today, significant strides in technology and process have made it much more competitive and offshore wind is competitive with fossil-power generation.

Technology advances by original equipment manufacturers (OEMs), excellence and maturation in engineering, procurement and construction in operations, and innovative financing have reduced the average lifetime net cost of offshore wind generation (LCOE) by 60 percent (exhibit), thereby undercutting onshore wind and solar prices.

The Japanese public, however, remains skeptical of offshore wind's cost competitiveness because of the island's added challenges of unfavorable wind conditions and deep waters. It is therefore imperative for Japanese players to calculate the cost of the full value chain in advance, from development to build and operations to ownership.

*Technology advancement* has accounted for nearly two-fifths of the cost reduction. Increasing the size of wind turbines to 9 and even 12 MW while boosting their productive their lifetimes from 25 to 30 years has significantly reduced capital expenditure per MW.

*Excellence and maturation in build and operations* accounted for one-fifth of the cost reduction. This was driven by increased competition between OEMs; economies of scale through larger park sizes and economies of skill in building the parks as well as operating and maintaining them.

*Innovative finance concepts* accounted for approximately 5 percent of the cost reduction by leveraging the cost of capital arbitrage between developers and financial investors. This occurred as offshore wind become a more mature asset class, thereby reducing required financial risk premiums compared to other renewable technologies and asset classes.

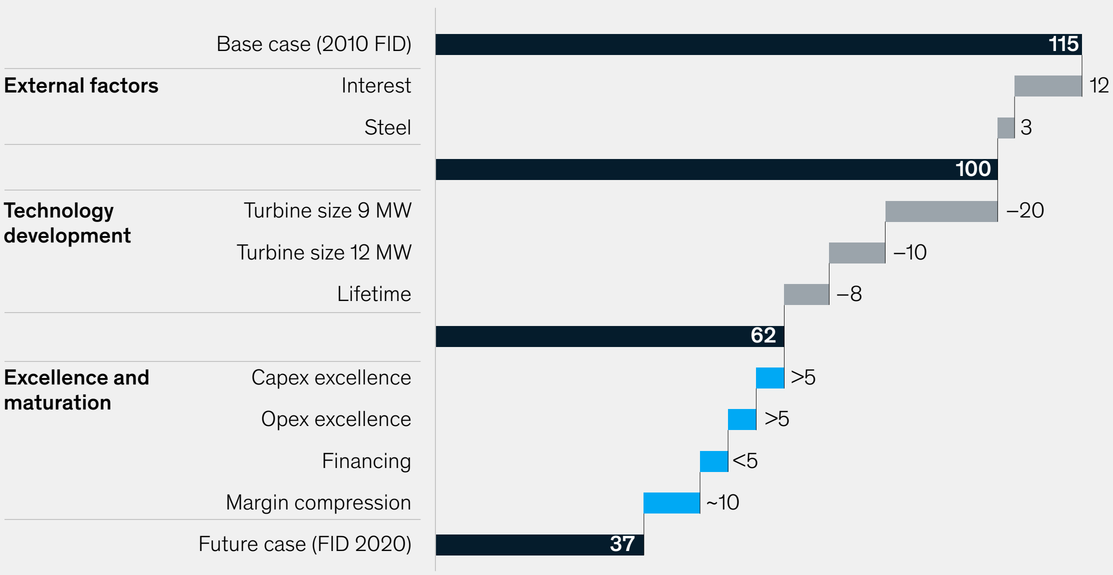
In the coming years we expect further cost reductions driven by technology advancements. For example, the first 14 MW turbines have been announced and increasing portfolio size and digitization opportunities will provide additional opportunities to reduce costs during the build and operations.

Exhibit

### Cost-reduction opportunities along the offshore wind value chain.

**Potential LCOE path,** €/MWh, normalized

Indicative




Source: Source: Fichtner/Prognos "Kostensenkungspotenziale der Offshore-Windenergie in Deutschland"; TKI Wind op Zee "Cost reduction options for Offshore wind in the Netherlands FID 2010–2020"; McKinsey analysis

Local geographic challenges, such as deep water, steep coasts, and wind speeds that are alternately too low or too high, make Japan's offshore wind energy more expensive than that of other regions, including Taiwan, Europe, and the East Coast of the United States. To achieve similar prices, Japan will need to cut the high feed-in-tariff levels of ¥36/kWh (about $300 per MWh) it is paying for its first six port and harbor projects. Only then will it be able to reduce the high LCOE[11] for these and future projects.

Case study: Taiwan and the United States have shown that moving quickly from a feed-in tariff to an auction-based model can significantly reduce the cost of developing offshore wind power. Implementing a clear process generates increased political will among key players, makes it easier to attract commercial partners, and ends the public misperception that offshore is too expensive to be a viable option.

2. *Additional appeal.* Japan must still convince a skeptical public that offshore wind power can overcome its geographic challenges and compete favorably with alternative energy sources. Beyond achieving cost competitiveness, as described above, this is a matter of good communication. Not only is LNG an expensive alternative that must be imported from suppliers as far away as Qatar and the United States, but offshore wind also comes with environmental benefits and the opportunity for job creation.

   Case study: The benefits of wind energy in the European Union have been clearly communicated to the public. For example, in 2016, WindEurope, the European wind association, forecasted that by 2020 offshore and onshore wind would create 290,000 jobs and avoid 238 Mt of $CO_2$, while reducing fossil fuel imports by €27 billion and adding €42 billion to the GDP.[12]

3. *Pipeline certainty.* Japan will need to be clear about the scale of the offshore wind capacity that will be built over at least a decade and give stringent annual targets. Otherwise, it will be difficult for public and private stakeholders to align. Only then will companies finance and engage in large infrastructure projects and create a local supply network.

   Case study: In the United Kingdom, clearly communicated build-out targets and a corresponding remuneration framework created the required security for investors and suppliers.

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[11] The levelized cost of electricity measures average cost of electricity generation over the lifetime of the generating wind farm per generated unit.
[12] "Local impact global leadership," WindEurope, windeurope.org.

For example, SiemensGamesa launched its commitment in 2001 and installed its 1,000th direct drive offshore wind turbine on the Anglian coast in late 2019. Japan has begun its own journey by announcing build-out targets and would do well to consider a similar framework and set of targets for its supply chain.

4. *Local industry policy.* The right regional economic policy and infrastructure, including suppliers, transport, and human resources, are necessary to attract offshore wind energy investment to those places with the right wind conditions. Other regional factors that will influence investment decisions include favorable environmental regulation, fast-track approval procedures, and financial support, especially in the early stages. Local infrastructure and employment goals and guidelines should be developed by prefecture according to overall country objectives. This is particularly relevant for engineering, procurement, and construction of port infrastructure, equipment factories, or outlets, such as turbine operation and maintenance hubs (see sidebar "Core levers in engineering procurement, and construction"). Prefectural goals for local infrastructure and job creation must be balanced with the need to create a competitive market.

## Core levers in engineering, procurement, and construction

**Most offshore wind projects** have been constructed within expected timelines and on budget, but only because of large contingencies in the initial planning. McKinsey diagnostics on projects in Europe show that 60 percent of all activities in the schedule would have overrun had it not been for these larger than normal buffers.

Applying design and execution levers during the engineering, procurement, and construction phase has the potential to reduce lifetime net costs by 15 to 25 percent. The greatest potential cost savings can be made in turbine and installation capex. Even so, we have identified improvement potential in all the steps along the value chain.

*Applying end-to-end project planning* that links the engineering, procurement, construction stage and integrates the perspectives of all parties, including owner and all contractors, into one master schedule, can significantly reduce the project's variability. From this schedule, all milestones are jointly planned. Actionable targets are set every three to four weeks, while a detailed plan is devised for the immediate week ahead.

*Identifying technical improvements in the engineering and design phase* for all main elements of the project can reduce capital and operations expenditure. Effective tools include design-to-value and further standardization and modularization of the major components. Digital twins, for example, can help verify certain options before they are implemented.

*A procurement and contracting strategy* can have a large effect on project delivery and costs. Options include traditional contracting, such as engineering, procurement, and construction, EPC + management, owner integrated, and more collaborative models, such as integrated project delivery. Using best-practice contract negotiations and the most advanced procurement tools can help to further reduce project costs.

*Implementing a control tower* during construction can improve performance. It serves as a forum in which owners and contractors share the performance of the project. Actual is tracked against planned on a daily basis. This is accompanied by a joint issue resolution and debottlenecking, if needed. Advanced tools, such as digital control towers or 5D building-information modeling with real-time tracking of people, processes, and material flows, can also support the construction.

Case study: In Taiwan, the local content requirement led to challenges for early international developers. The companies struggled to assure local, high-quality supply of some components. Japan can avoid these problems by issuing early and clear guidelines.

5. *Transmission and distribution.* Two other areas need careful planning: first, the onshore grid capacity and cost alignment; second, the incentive alignment between generator and transmission grid owner. Though there are lesson to take from previous experiences, offshore transmission, and onshore landing grid build-out and its regulations can be highly country specific.

   Case study: Germany initially pursued a centralized transmission development plan in which the transmission systems operator was put in charge of building out the grid for the offshore wind farm. The approach failed to deliver the required connections in time, in part because of inadequate prioritization. The wind farms were left stranded and needed to be run on diesel to avoid complete failure. The problem was solved by moving to a cluster model in which the transmission grid was built before the wind farm.

   The United Kingdom took a different approach. It found success with a decentralized model in which the responsibility for building the transmission grid lay with the wind farm's developer. Japan can learn from both experiences as it establishes a model where the development of the transmission grid and the wind farm are synchronized.

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Japan has good reason to pursue offshore wind energy and has picked an opportune moment to join the international scale-up club. Not only does developing offshore wind offer a way to stimulate the economy in one of the most severe global downturns in living memory but also the industry itself has made great strides across the globe since its inception in Denmark in the 1990s. Taiwan and the United States, in particular, have shown the advantages of taking on the lessons of pioneers, such as Germany.

Undeterred by deep water and difficult wind conditions, Tokyo has begun to build the foundations to meeting its sizable wind energy potential and shifting away from coal, nuclear, and foreign suppliers. Many of the country's unique challenges are also its greatest opportunities. With rigorous stakeholder alignment, coherent market design, and supportive regulatory and financial conditions, Japan could become an industry leader in developing the technology and processes needed in deep water and challenging wind conditions.

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