Stimulating Offshore Wind in Nova Scotia

Aegir Insights

Prepared for NZA (Net Zero Atlantic)

Final report

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Abbreviations

BEIS = Department for Business, Energy & Industrial Strategy (UK government)

BOEM = Bureau of Ocean Energy Management (U.S. federal government)

BOP = Balance of Plant (Turbine foundations)

BSH = Federal Maritime and Hydrographic Agency (German government)

CfD = Contract for Difference

COD = Commercial Operational Date

DEA = Danish Energy Authority (Danish government)

EEZ = German Exclusive Economic Zone

EIA = Environmental Impact Assessment

EIS = Environmental Impact Statement

FiP = Feed-in-Premium

FiT = Feed-in-Tariff

GIS = Geographic Information System

GW = Gigawatt

KW = Kilowatt

LCOE = Levelized cost of electricity

MW = Megawatt

Ofgem = Office of Gas and Electricity Markets (TSO in UK)

OREC = Offshore wind Renewable Energy Certificate

OSW = Offshore wind

OWF = Offshore Wind Farm

PPA = Power Purchase Agreement

PtX = Power-to-X

REC = Renewable Energy Certificate

RES = Renewable Energy Standard

RPS = Renewable Portfolio Standard

TCE = The Crown Estate

TSO = Transmission System Operator

WTG = Wind Turbine Generator

Executive summary

Nova Scotia holds many of the prerequisites for attracting the global offshore wind industry and making offshore wind play a key role in the region's future energy mix and economic growth: World class wind speeds, strong maritime research institutions and a solid industrial base with workers well versed in shipbuilding and steel manufacturing.

Offshore wind power will not be able to compete on price with hydropower and land-based wind from day one, but it offers Nova Scotia a local, large-scale source of green energy that will provide increased energy independence as well as long-term jobs and socio-economic benefits.

The main obstacle for attracting offshore wind developers to Nova Scotia lies in the relatively modest energy needs of the province, limiting the scope of build-out to only a few offshore wind parks if the sole objective is to supply power for provincial use.

For this reason, Nova Scotia should see investments in attracting offshore wind projects as a way to not only supply the province's own immediate power needs, but also set up Nova Scotian businesses to be able to participate in refining the technologies of tomorrow such as power-to-X and/or to play a part in the substantial offshore wind market set to emerge on the U.S. East Coast within the decade.

In this report, Aegir Insights outlines and evaluates selected experiences of other, more mature offshore wind markets to glean lessons learned and advice on what steps Nova Scotia should take, if the province wants to pursue offshore wind as part of its energy mix.

Fifteen specific recommendations for promotion of offshore wind in Nova Scotia are provided, spanning:

- Official targets for the capacity of offshore wind the province wants to see deployed within a certain timeframe; a short-term target of 1 GW by 2030 and a long-term target of 5+ GW by 2050 are suggested
- Centrally led siting of projects to de-risk market entry for leading developers
- Feed-in-Tariff or Contract-for-Difference renumeration schemes to make projects bankable
- Establishment of a one-stop-shop approach to leasing and permitting procedures, building upon the current regulatory framework of the Canada-Nova Scotia Offshore Petroleum Board
- Enabling a radial-approach to transmission design and a developer-led grid connection
- Support of local, economic development through a task force enabling investments into transitioning the existing workforce and supply chain to offshore wind while simultaneously educating a new work force

- Preparation of infrastructure (ports, transmission) to support offshore wind build-out in Nova Scotia and potentially the U.S. East Coast.

Finally, taking a more long-term strategic view, the report suggests that Nova Scotia looks beyond the time horizon of 2030 and the immediate goal of more renewable power for Nova Scotia to consider what complementary technologies could position the province to attract leading international investment in the local supply chain and develop valuable intellectual property.

Two opportunities are suggested for Nova Scotia to attract extra investment interest:

- Hybrid energy systems – combining offshore wind with long duration storage, hydrogen production or other power-to-X conversion technologies will be key strategies for optimizing offshore wind as an energy source going forward and first movers around the world are in the process of testing these technologies
- Floating offshore wind – Nova Scotia could host the first large scale demo or commercial project on the East Coast of North America.

1 Introduction

1.1 Background & Objective of study

NZA is an independent, not-for-profit research organization that funds research aimed at reducing risk and encouraging the sustainable development of Nova Scotia’s energy resources. NZA supports research into renewable energy technologies, cleantech initiatives and geoscience by facilitating collaborative, made-to-order teams of experts.

This report is issued by NZA in the context of a collaborative program funded by the Nova Scotia Department of Energy and Mines. This work supports the Province’s broad energy policy objectives related to climate change, inclusive economic development, and the sustainable development of Nova Scotia’s energy resources.

Nova Scotia has set the target to become a net-zero greenhouse gas (GHG) emission economy by 2050. The pathway to reaching this important milestone will include a portfolio of decarbonization strategies, one of which is the electricity generation system decarbonization and subsequent electrification of end-uses. Electrification will increase the total and peak electricity demand in coming decades.

Satisfying the additional electricity demand will likely not be possible with the existing electricity system infrastructure. Investments in the electricity generation system will be necessary. It is therefore important to understand which options to produce low- and no-carbon electricity are technically and economically viable in Nova Scotia.

One of the options for Nova Scotia is tapping into its wind resources. With more than 500 MW of onshore wind in operation, Nova Scotia has one of the highest penetrations of wind energy into the electricity grid of any jurisdiction in North America. While onshore wind development is well-established in Nova Scotia, there is currently no offshore wind development in the Province.

To attract offshore wind investment to Nova Scotia, it is important to understand the development in other jurisdictions. For example, Europe has developed, and the USA are developing, an active offshore wind industry encompassing the entire supply chain. If Nova Scotia developed offshore wind in its coastal waters, it would compete for investment against these jurisdictions. Naturally, investors often select locations with minimized investment risks. It is important for the Province to understand what economic and policy conditions could minimize investor risk and be used to attract investment in Nova Scotian offshore wind developments.

The objective of this report is to further the understanding of how offshore wind development could be stimulated in Nova Scotia.

1.2 About Aegir Insights

Founded in 2018, Aegir Insights is an offshore wind investment advisory and analytics firm developing the sector's most advanced tools for policy and investment research. Aegir is founded by highly experienced commercial and strategy experts coming from world leading offshore wind developers, having extensive experience in new market entries, regulatory frameworks, project development, and competitive auctions. Apart from analytics tools, Aegir provides deep commercial research and datasets for clients, supporting assessment of emerging offshore wind markets.

Aegir prides itself on building long term relationships with clients which include governments, developers, and investors, helping them make better decisions, faster.

1.3 Scope & Methodology

This report starts by mapping out the overall trends seen in global offshore wind development today. Then the main policy tools and initiatives used in other jurisdictions for promoting offshore wind development are examined. The jurisdictions in focus are Denmark, the UK and Germany representing mature markets, and certain U.S. East Coast states representing a nascent market which is also geographically close to Nova Scotia. A few examples from South Korea, being another early-stage offshore wind market, are used to further illustrate how new markets attract industry attention. The analysis is based on empirical research of best practices for development and build-out of an offshore wind industry.

Hereafter, Nova Scotia's current electricity mix and demand, economic conditions and readiness of existing infrastructure and industry will be presented. Apart from existing empirical research, our insight is based on interviews with the Nova Scotia Department of Energy and Mines that have been conducted from January to March 2021.

Finally, considering what has been done in other jurisdictions as well as Nova Scotia's current situation, the report evaluates relevant policy tools and promotion initiatives for making offshore wind energy a part of the solution to meet the newly announced renewables target for Nova Scotia of 80% by 2030.

The recommendations for Nova Scotia are ultimately presented in the form of a roadmap that outlines the broad range of enabling actions that are recommended to the Government of Nova Scotia to make offshore wind an attractive alternative to fossil fuel generation and to attract investment and obtain economic benefits. Whereas the first part of the recommendations is focused on policy tools and "safe bets", the second part will suggest innovative initiatives as "wild cards".

At this early stage, results are preliminary and based on desktop studies. They are intended to form the basis of consultations between relevant government branches, industry, and other stakeholders.

1.4 Limitations

The scope of work includes a jurisdictional scan of the policy and economic conditions in jurisdictions with an established or emerging offshore wind industry. The scans are meant as general overviews and should not be viewed as complete guides to other jurisdictions' models for attracting offshore wind development.

Each jurisdiction must find its own way to offshore wind development under different conditions arising from its political, social, and natural environment. Since Nova Scotia has both unique characteristics and will be beginning its offshore wind development later than any of the jurisdictions it is compared to in this report, the experience will not be entirely the same. The fact that Nova Scotia would be beginning its OSW development in a more mature market globally than the other jurisdictions has been accounted for, by for instance expecting a faster drop in LCOE. Easier access to both knowledge and initial costs relative to the experiences of Denmark, the U.K., Germany, and the U.S. is also assumed, including possible benefits of the proximity of the emerging offshore industry on the U.S. East Coast.

Aegir Insights has agreed to the publication of this report. To the maximum extent permitted by law, Aegir Insights is not responsible for any loss you or any other party may suffer in connection with the access to or use of this report. The recommendations in this report do not constitute legal advice and no guarantee about their effects is made.

2 The offshore wind market today

2.1 Offshore wind development and build-out expectations

Offshore wind is a rapidly maturing renewable energy technology that has become key to power sector decarbonization in several jurisdictions on account of its scale, industrialized supply chain and its emergence as one of the most cost competitive renewable energy sources. The growth of the offshore wind industry was initially fostered in European countries bordering the North Sea, where there is a confluence of exceptional wind resources and relatively shallow water depths, conditions which together make for highly competitive levelized energy costs.

The European markets nurtured the development of offshore wind technology through relatively forward thinking and stable policies from the period of 2010 onward, resulting in an achievement of nearly 25GW installed capacity as of 2020, predominantly in the United Kingdom, Germany, Belgium, the Netherlands and Denmark as seen is **Figure 1.** In recent years offshore wind has been rapidly internationalized with the United States and much of Asia expected to commercialize through the 2020s.

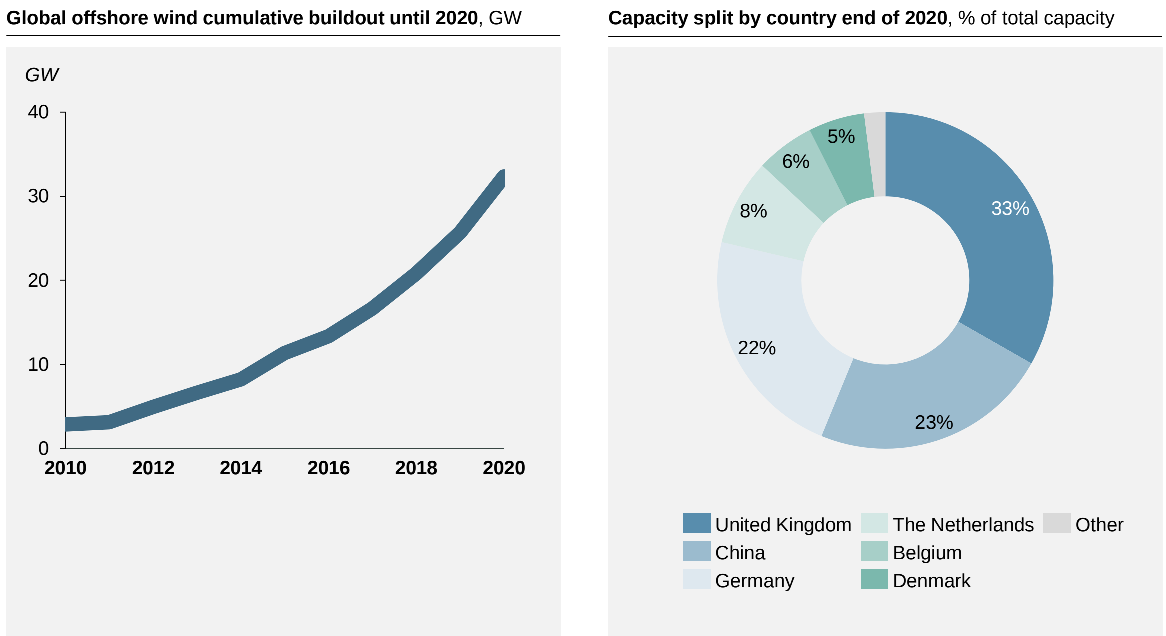
The Asian market buildout will begin in China before quickly spreading to Taiwan, South Korea, Japan and Vietnam. The U.S. is expected to take-off sometime in the middle of this decade, with most capacity in the early days coming from the East Coast.

These emerging offshore wind markets benefit from policy and supply chain lessons from the pioneering European markets, and thus are expected to experience relatively fast costs reductions as projects reach commercial scale. There is also a wide range of further technology improvements that are promising steep cost reductions in the near term, after which incremental improvements should be expected with some degree of continuous learning curve effects.

Today, offshore wind is a multi-billion-dollar industry with developed supply chains in leading markets that span development, project construction and installation, operation and maintenance, and decommissioning activities. European companies have until now held leading position in ownership of offshore wind projects and are leading the expansion to new markets. The large energy utility incumbents such as Orsted, Vattenfall, RWE and Iberdrola have historically dominated in terms of market share, but new entrants such as pension and infrastructure funds, oil majors and various sized independents are pushing the boundaries in terms of competitiveness and accelerating the industry’s global expansion.

Looking towards 2050, 1,000 GW offshore wind capacity could be in operation according to projections by the intergovernmental organization International Renewable Energy Agency's (IRENA) analysis (IRENA, 2019).

Figure 1: Global offshore wind cumulative buildout until 2020 and capacity split by country end of 2020

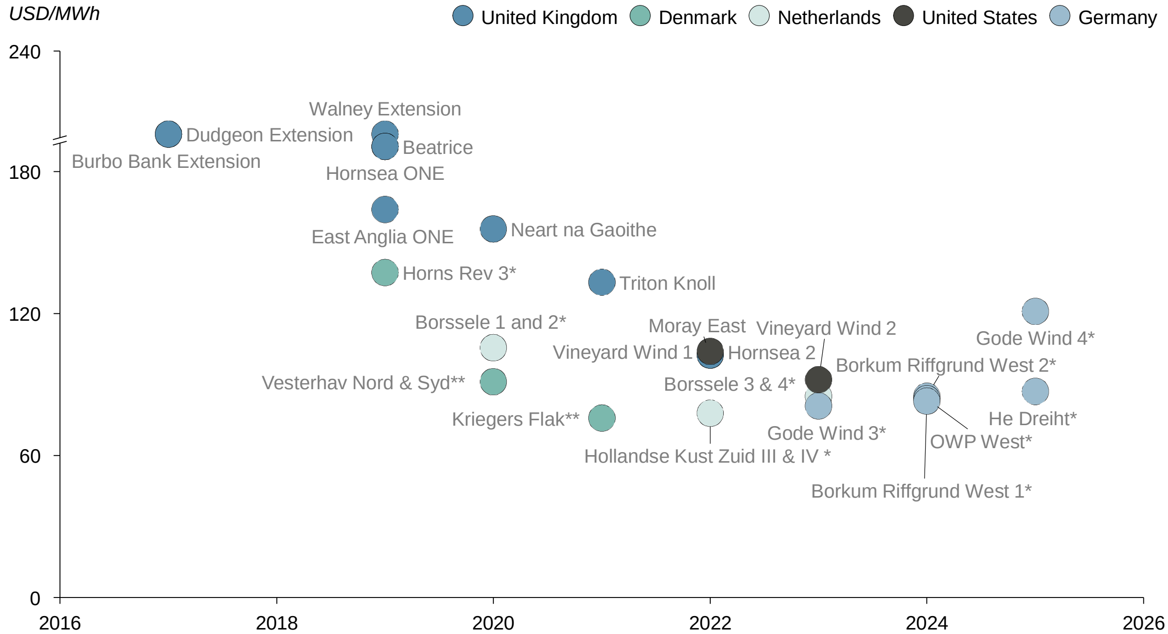


2.2 Cost trajectories and supply chain development

The offshore wind industry has gone through dramatic cost reductions over the last five years and has recently demonstrated that it can be cost competitive with non-renewable power sources. This was demonstrated with the advent of 'subsidy free' bids in both Germany and the Netherlands for OSW project delivery between 2022 and 2024 (Deign, 2018). Based on levels as high as 200 USD/MWh in 2017 in some jurisdictions, offshore wind prices have declined on average by ~60% to today as seen in **Figure 2**.

The industry's rapid cost decline has come about through a number of factors, including but not limited to historically low capital costs, rapid scaling up of turbine capacities, moving to continuous supply chain 'factory' operation and continuous offshore installation activities. Furthermore, the supply chain has demonstrated that its industrialized approach can deliver very low construction risk premiums.

Figure 2: Adjusted strike prices from U.S. and European offshore wind auctions (Beiter e. a., 2019) in USD/MWh

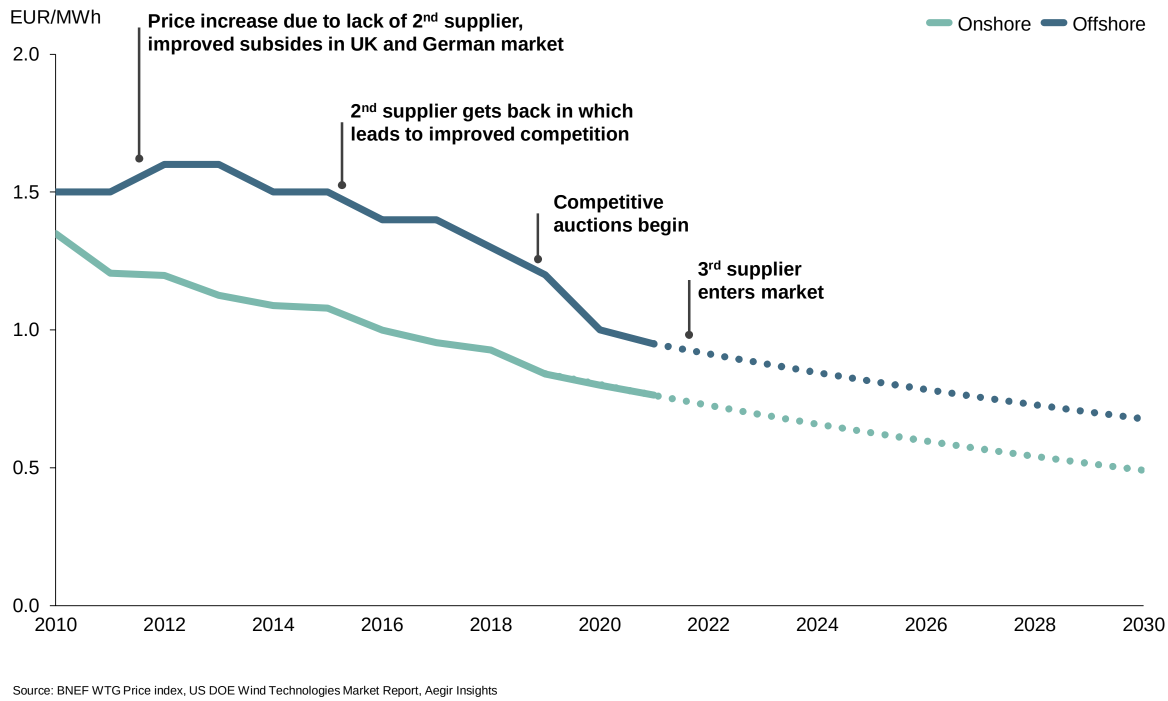


(*) Grid and development costs added;
(**) Grid costs added, and contract length adjusted; includes data for commercial-scale projects only

One of the key drivers of lower offshore wind prices are the declining costs of Wind Turbine Generators, illustrated in **Figure 3**. The offshore wind industry has a relatively low number of offshore wind turbine suppliers compared to the onshore wind industry, mostly due to company consolidations and challenges regarding profitability for new entrants. Up until 2020, there has generally only been two to three offshore wind turbine manufacturers with bankable technology in play. The resulting limited competition led to offshore wind turbine prices not experiencing the substantial price decline of the parallel onshore wind segment during most of last decade. However, towards the end of the 2020s, GE made a credible entry into the European market, while the Asian markets saw the emergence of offshore wind turbine suppliers from its existing onshore base. This increasingly competitive environment in conjunction with competitive tenders has already contributed to substantial cost reduction, and turbine prices are expected to fall incrementally going forward.

As seen in **Figure 3**, the offshore wind turbine price trend has now converged with onshore wind turbine prices (but offset still).

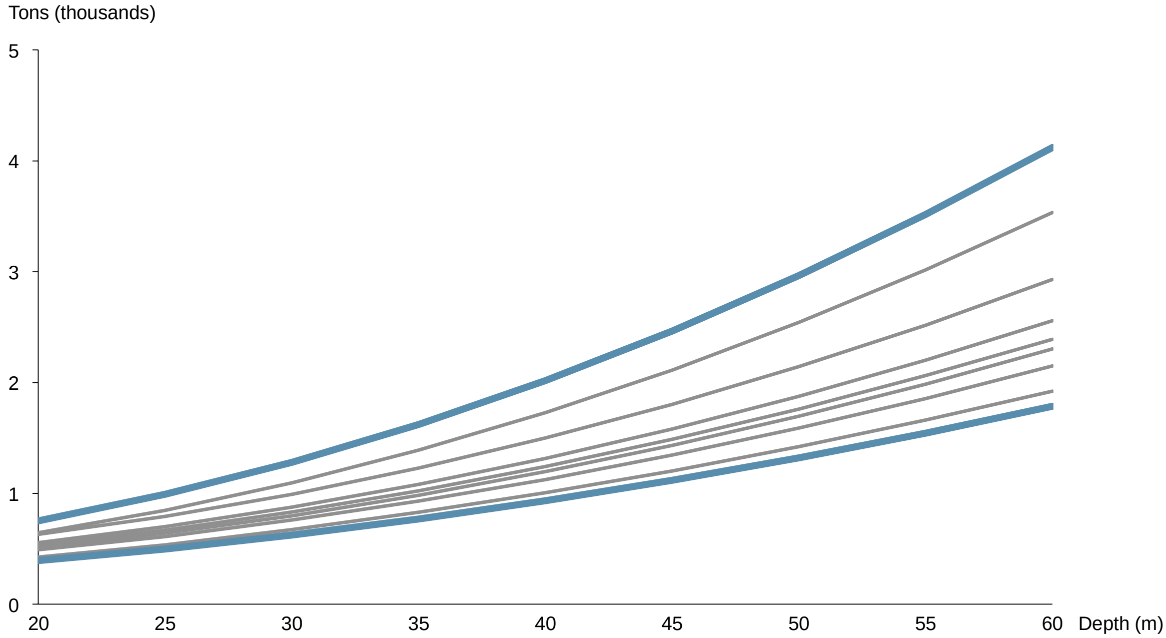
Figure 3: Price development of Wind Turbine Generators (WTGs)



Offshore wind turbines have also continuously increased in size, providing substantial benefits in terms of economies of scale for their own cost base, and affecting the balance of plant in a positive way due to fewer turbines being required to achieve the same capacity.

The tradeoff from turbine evolution is that the surrounding supply chain must remain highly adaptable and dynamic in order to keep up to speed. An example of this is offshore wind foundations. Monopiles account for over 85% of offshore wind installations to date and have been forced to continuously scale up due to increased loads from heavier and taller wind turbines. Monopiles are now increasingly reaching the limits of what can feasibly be installed, but tonnage savings and new vessels are expected to maintain the position of the monopile as the leading foundation technology for now. The evolution of monopile foundation tonnage trends are shown in **Figure 4**.

Figure 4: Weight of WTG foundations in relation to water depth



Source: Aegir analysis from 4C offshore, and scaling model

Other notable technology trends in the offshore wind industry include inter-array cables having moved from 33kV to 66kV, allowing installation of more turbines per string, and the move to year-round installation of components (versus only summer) which has come from having purpose-built vessels.

In aggregate, the rapid innovation has meant that both developers and suppliers need to be forward looking to future technologies and ensure that project consenting, and procurement remains flexible enough to let projects adopt the latest trends. This has also played a role in the supply chain, where local facilities must plan to accommodate the rapid growth of technology to be sustained.

2.3 Emerging technologies

A number of emerging technology opportunities in the offshore wind sector are highly relevant for policy planning over the coming ten years and beyond. Key emerging technologies relevant to Nova Scotia's policy planning are introduced in the following sections.

2.3.1 Energy system integrations

As intermittent renewable electricity sources, such as solar and offshore wind, grow to account for a larger apart of the electricity generation mix, an issue of grid balancing appears. Energy system integration can create a more reliable electricity supply by balancing out the system when renewables are fluctuating.

Beyond grid balancing, converting electricity to other energy carriers is of special interest. This has opened the market for Power-to-X (PtX) technologies. PtX refers to the conversion of electricity from renewables, such as offshore wind, into other energy carriers or products. Converting electricity to other energy carriers makes the power more versatile and easier to store. One way of processing electricity is through the production of hydrogen (H2) by splitting water in an electrolysis process. If the electricity comes from renewable sources, the hydrogen is called “low-carbon hydrogen”.

Hydrogen can either be used pure or be transformed into other types of gases or liquids such as methane (CH4) or ammonia (NH3). There is a diverse range of applications for hydrogen or hydrogen-based products such as fuel in transport industry, as chemical feedstock or powering of steel, cement and refinery industries, re-powering of power plants and in the gas grid to heat up homes.

As offshore wind technologies are maturing, developers, investors and policy makers are recognizing offshore wind’s potential to produce energy system integration projects at low cost and large scale. Hence markets are moving towards encouraging solutions which are hybrid or combined with various forms of system integration technology.

2.3.2 Floating wind

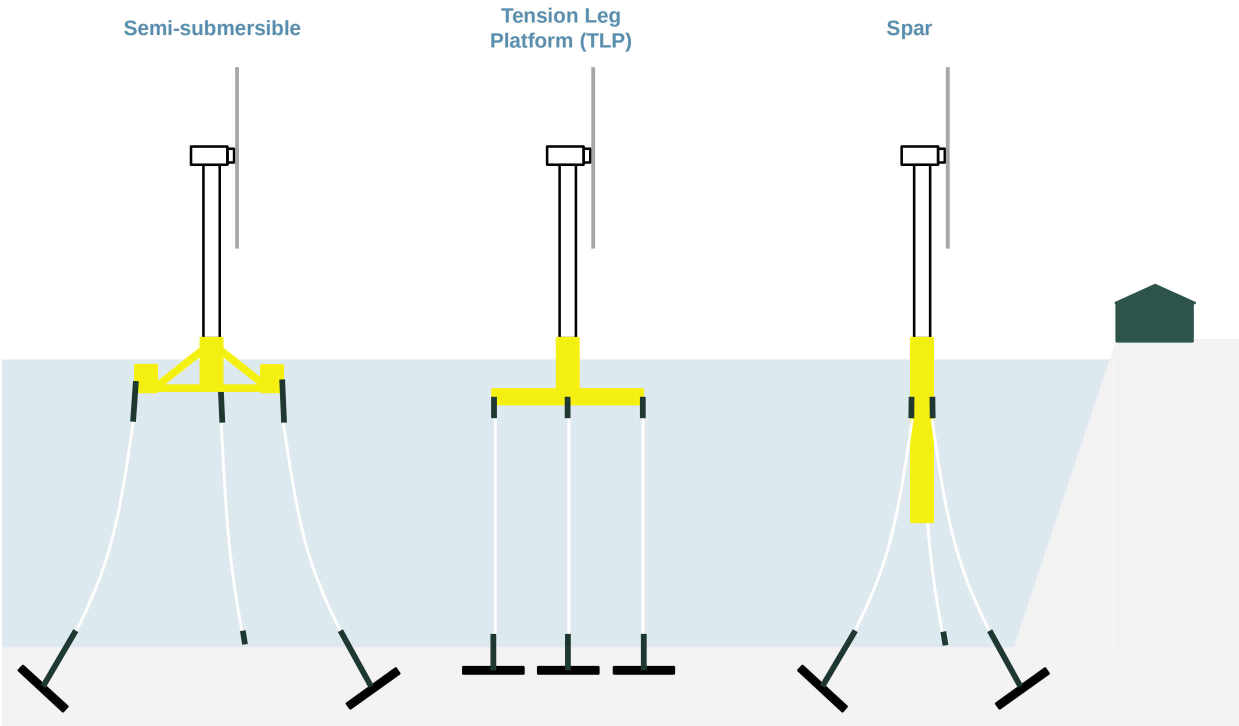
A wind turbine positioned on a fixed-bottom foundation has the disadvantage that it needs to be connected to the seabed. This limit fixed-bottom offshore wind parks to a maximum depth of 40-60 meters, as dimension, tonnage and installation in deeper waters become too complex and costly.

Hence, fixed-bottom technologies are not suitable for expansion into markets where shallow water is not available on a large scale, and even within fixed-bottom markets, factors such as low wind resources, viewshed issued or seabed conditions often limit large-scale built-out in the shallow waters.

Floating foundations overcome the issues of deep waters that are found in many markets globally and can help achieve continued build-out in markets that are running out of feasible shallow sites due to viewshed issues and more.

With this technology, the wind turbine is positioned on a floating foundation that is only connected to the seabed with anchors and mooring lines. Current floating wind concepts are illustrated in **Figure 5.**

Figure 5: Illustration of floating wind concepts



Floating wind is still a young technology, but it is very promising. Not even 100 MW of floating wind is operational yet, but the only commercial project in operation, Equinor ASA’s Hywind Scotland, has so far performed well in terms of deployment and operation. Two floating projects – Kincardine in Scotland (48 MW) and Hywind Tampen (88 MW) – are in the construction and pre-construction phase, respectively.

Although it is a young technology, it is not short of interest from large energy players. Traditional offshore wind players see it as a step to innovate and expand into untapped markets. Entrants from the oil and gas industry are also showing interest in floating wind. Due to the similarities in technical specifications of floating wind and floating offshore oil & gas platforms, oil and gas companies see it as an opportunity to move away from fossils towards greener alternatives. Equinor and Shell are amongst the oil majors that have floating wind projects at various steps around the world.

2.4 Offshore wind development timeline

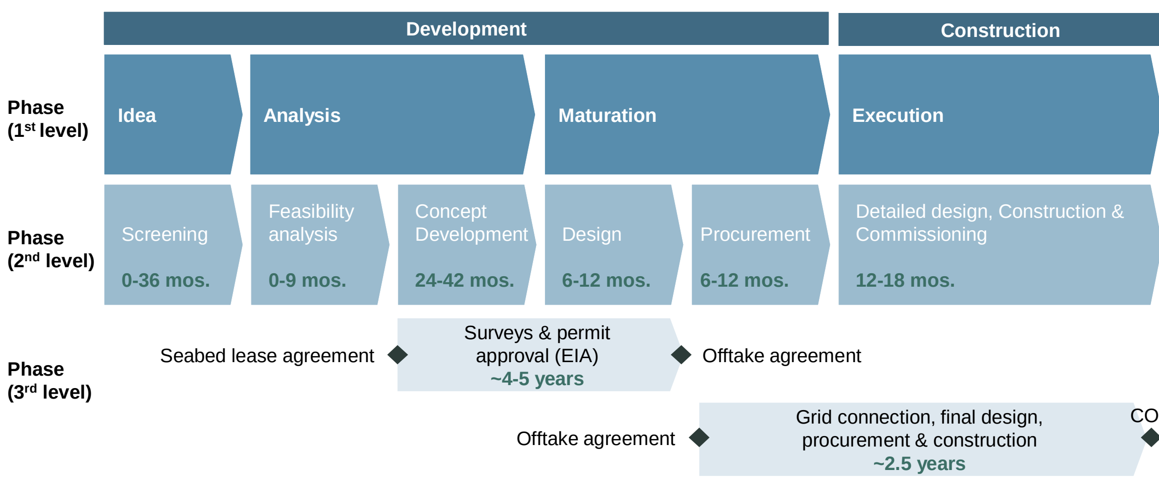
As offshore wind farms are installed under harsh conditions at open sea, the development phase including planning and consenting is lengthy, taking an average of 4-5 years or more, and accounts for ~10% of the total capital expenditures.

The procurement and manufacturing of key components for the offshore wind farm generally take 1-2 years, followed by 1-1.5 years of installation. When an offshore wind farm is installed, generates power and is fully commissioned, it enters the operation and maintenance phase for 25-30 years or more (Truepower, 2015).

As the focus of this report is the initial enabling conditions for offshore wind development in a new offshore wind market, the activities included in the development phase will be covered in more depth.

Referred to as the ‘screening’ and ‘feasibility analysis’ sub-phases in **Figure 6** below, these very first steps are the phases where government regulators determine the market policy tools and processes for offshore wind development. The initial regulatory framework design is thus key to how the developers and investors view and assess the risks and opportunities associated with the emerging offshore wind market, compared to other offshore wind opportunities in competing jurisdictions.

Figure 6: Generic timeline for development and construction of an offshore wind farm



Existing practice for screening of potential sites for offshore wind development, including constraint mapping of other uses and initial data collection will be discussed in Section 3.3.4.

3 Policy and economic conditions in competing jurisdictions

3.1 Stimulating offshore wind development in mature markets

In this section, a group of jurisdictions representing the main types of offshore wind promotion models will be mapped. Policy tools and other instruments used to attract investment in offshore wind development will be analyzed and discussed. The jurisdictions examined are mainly Denmark, United Kingdom, selected U.S. states, and Germany.

Furthermore, examples of policies promoting system integration and hybrid solutions in connection with offshore wind development, as well as promotion of domestic supply chains and skills development will be presented.

3.2 Vision and target-setting: A tool universally used

Figure 7: Target-setting, timeline and drivers in selected jurisdictions

Denmark

- Clear and ambitious driven by reduction in CO2 emissions and energy security
- No OSW target, but carbon neutral ambition by 2050

Germany

- OSW target of 20 GW by 2030, 40 GW by 2040
- Carve-off nuclear initial driver, 65% power production from renewables by 2030

United Kingdom

- Ambitious driven by 80% cut in CO2 emissions by 2050
- While oil & gas decline, OSW should guarantee energy security

United States

- Build-out is driven by states' OSW targets
- OSW targets are part of ambitious state RPS's

Introducing a renewable energy target with a sub-target for offshore wind is a widespread approach of gaining the interest of the global offshore wind industry, and the first time a target is announced, it tends to be viewed almost akin to a starting gun going off.

For instance, when Connecticut's first target for offshore wind development was announced in 2019, the Yale-produced media Clean Energy Finance Forum described it as an action-filled start to a race:

> *“After years of testing the waters, Connecticut has finally jumped into the offshore wind game with a recently passed target of 2,000 megawatts (MW) by 2030* (Seigner, 2019)*.”*

Thus, when a government announces an official target for offshore wind development, it immediately gains the attention of and clarifies to the industry how big the market in question will be. The setting of official targets also works as a signal that the policy environment can be relied on for many years.

A review of targets that have successfully attracted offshore wind to competing jurisdictions reveal three lessons learned, summarized in the following sections.

3.2.1. Short term targets should be realistic – long term targets ambitious

In this report we define short-term targets as targets that stretch less than 15 years into the future.

All targets should be both ambitious and realistic, but it is especially important for the short-term targets to be within the realm of what is possible, as the short-term targets should be accompanied by a roadmap detailing how to get to the desired capacity. However, the short-term target should still be ambitious, effectively reflecting a reality where everything works out in the optimal way.

In 2010, the UK set a target of 12 GW of offshore wind power by 2020. While this target was not reached entirely, the UK still experienced a boom in offshore wind build-out following the target-setting, going from around 1 GW offshore wind in 2010 to around 10 GW in 2020. The target was thus ambitious enough to attract a lot of offshore wind development but realistic enough that reality did not fall too far short of expectations.

In October 2020, the UK government announced a new target of 40 GW of offshore wind by 2030. (UK Government, 2020). This very ambitious target was announced less than four months before Round 4 of auctions for seabed leases under The Crown Estate (TCE), where prices paid in upfront option fees went very high. While the prices paid for option fees in Round 4 have been criticized for being too high, they confirm the high level of interest in developing offshore wind farms in UK waters, which could be partly due to the high government targets.

In the U.S., state governments on the East Coast have been the drivers of offshore wind development in the country so far with their high RPS targets including ambitious carve-outs for offshore wind.

Target offshore wind capacities of East Coast states have so far continuously gone up in a race between the East Coast states to procure capacity **(Figure 8)** from the limited number of available lease areas in the Atlantic Ocean.

Again, we see that ambitious but realistic short-term targets have likely helped the U.S. East Coast attract industry attention: As of March 2021, BOEM has awarded a total of 15 active leases in the Atlantic off the East Coast, accounting for more than 20 GW.

Long-term targets should also be within the realm of the possible, but with more emphasis on ambition. Long term targets need to demonstrate vision.

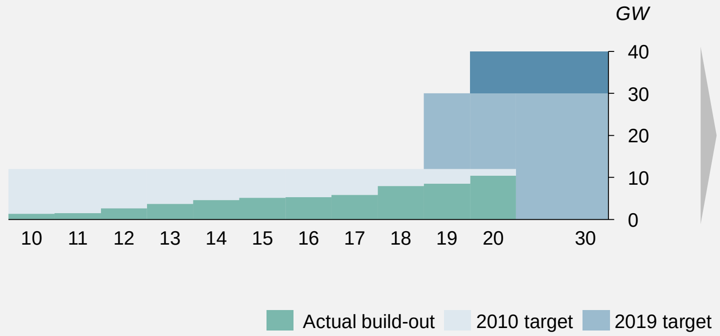
For instance, in Germany, a 2020 amendment to the offshore wind act WindSeeG increased the country’s short-term target from 15 GW to 20 GW by 2030 and introduced a long-term target of 40 GW by 2040.

Raising the short-term target by 5 GW was a small adjustment, while the long-term target of 40 GW is very ambitious and was praised for providing investor confidence an enabling better planning:

> *”The new long-term expansion target of 40 gigawatts by 2040 is an important planning basis for value creation and employment along the entire offshore wind supply chain.”*
>
> *– Heike Winkler, Managing Director at WAB, German Wind Energy Agency.*

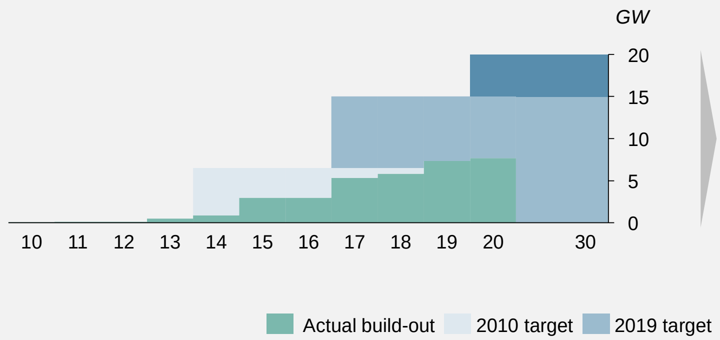
Figure 8: Graphs depicting offshore wind targets and build-out through the years in the UK, Germany and selected U.S. states

Offshore wind targets and actual build-out in the United Kingdom



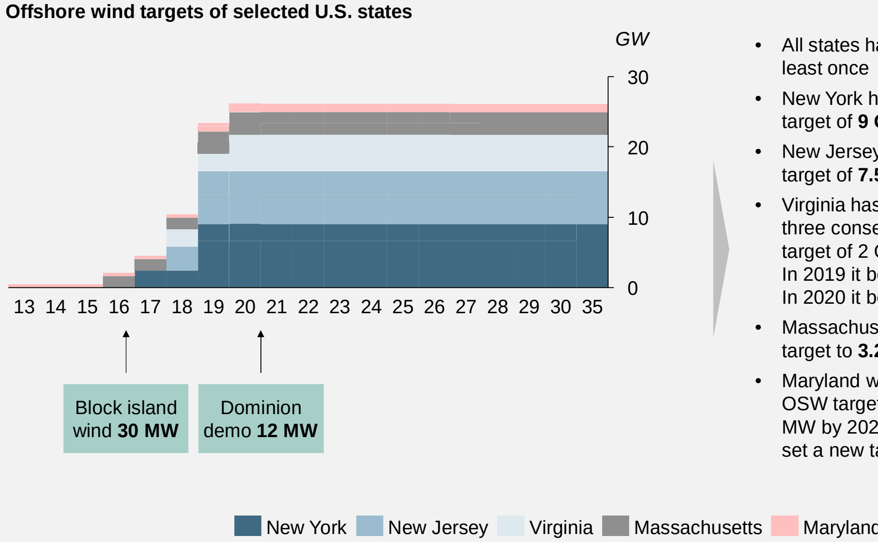
- Target of **12 GW by 2020** set in 2010 was not entirely met, but the decade still saw an impressive build-out
- A new target of **30 GW by 2030** was set in 2019
- In 2020 the previous target was raised to **40 GW by 2030**

Offshore wind targets and actual build-out in Germany



- Target of **6.5 GW by 2020** set in 2014. This target was met in 2019
- A new target of **15 GW by 2030** was set in 2017
- In 2020, the target was raised to **20 GW by 2030**

Offshore wind targets of selected U.S. states



- All states have raised their targets at least once
- New York has the most ambitious target of **9 GW by 2035**
- New Jersey comes in second with a target of **7.5 GW by 2035**
- Virginia has raised its targets for three consecutive years: In 2018, a target of 2 GW by 2028 was set. In 2019 it became 2,4 GW by 2026. In 2020 it became **5.2 GW by 2034**
- Massachusetts recently doubled its target to **3.2 GW by 2030**
- Maryland was the first state with an OSW target when they targeted 480 MW by 2020 in 2013. In 2019 they set a new target of **1.2 GW by 2030**

3.2.2 The target should be accompanied by a roadmap

Publishing a roadmap to achieving the offshore wind target shows that the government is committed and that the target is realistic. The roadmap should include initiatives that the government will take to facilitate offshore wind growth, and if possible, a rough timeline with interim goals towards achieving the target.

For instance, when the German federal Cabinet passed the Offshore Wind Act (WindSeeG) in 2016, which set a target of 15 GW offshore wind by 2030, it also published a roadmap for the realization of this goal (BWMI.de, 2017). The roadmap is still in use today even though the target has been raised to 20 GW and contains plans for auctioning off nearly 1 GW in 2021, 2022 and 2023, followed by 2.9 GW in 2024 and 3.5 GW in 2025. This timeline substantiates expectations for the German market.

Similarly, the offshore wind industry gained more confidence in the South Korean market when South Korea's government published the "OSW Collaboration Plan", a roadmap for meeting its target capacity of 12 GW offshore wind by 2030. The roadmap contains measures such as government-led siting, streamlined permitting, government-led stakeholder management through models for profit-sharing with local communities and more, thus providing a detailed overview of the government's way forward.

3.3 The allocation of site lease rights and siting

Figure 9: Seabed lease rights and siting in selected jurisdictions

Denmark

- Award includes seabed lease rights and offtake agreement, subject to EIS. Price as only tender criteria
- TSO performs all siting and surveys prior to auction

Germany

- BSH selects sites for auctions. Award includes rights to onshore grid connection and financial support
- Developers must submit relevant EIS material to BSH

United Kingdom

- The Crown Estate owns seabed and leases sites. Seabed zone rights rounds (volume short-listed)
- The developer must provide surveys suitable of an EIA

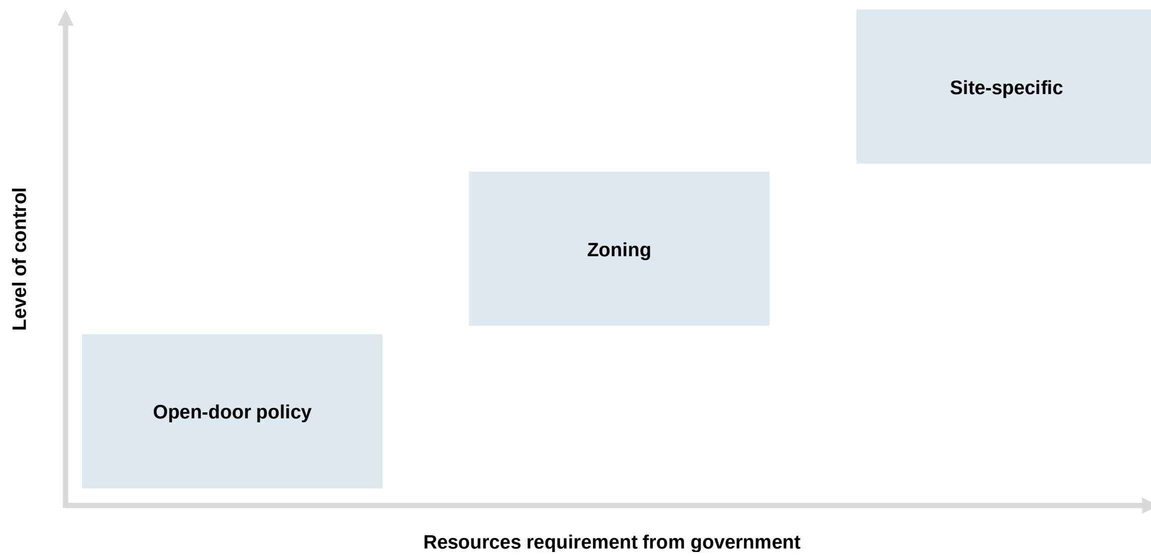
United States

- Seabed lease rights auction. Offtake criteria: price, local content system integration
- Developers with lease rights in federal waters must supply EIS survey data to BOEM

There are three main ways of determining where to build offshore wind farms:

- The **open-door policy** is easy to implement but provides little control over the build-out and may lead to a less efficient build-out as developers have to do a lot of groundwork, driving the cost up potentially resulting in more expensive offshore wind
- **Site-specific auctions** provide the most control to the government and enables a shorter and more simple process for developers, especially if combined with a one-stop-shop for permitting. However, it is more costly with regards to time and money spent by the government
- **The zoning approach** lies in the middle of the road, as it is easier to implement for the government than the site-specific approach but provides a little less control and a risk of higher leasing fees due to development costs and risks

Figure 10: Illustration of site allocation methods based on control and resources requirement from government



Zoning or leasing of specific sites are the two preferred methods of siting offshore wind farms among mature markets.

3.3.1 Open-door policy

Under an open-door policy, the developer chooses and applies for the use of sites and handles all relevant documentation, surveys, assessments, and stakeholder engagement. Many jurisdictions have this option but choose to use zoning or a site-specific approach most of the time.

The advantage of an open-door policy is that site development might happen faster, as it will be a competition between developers to identify and lay claim to the best sites first. The downsides are the lack of control over which sites get surveyed, lower chance for the government to ensure that the sites make sense in connection with the entire energy system and possibly less competition and higher electricity prices, as less developers will be interested in paying the up-front investments it takes to investigate sites.

Denmark has an open-door policy in place, under which a developer can submit an unsolicited application to carry out preliminary investigations into a site. However, the door is only open for unsolicited applications to develop areas that are outside the government-designated wind power development areas. As the Danish Energy Agency (DEA) regularly carries out screenings of potential sites and reserves them if they are deemed appropriate, this does not leave many truly viable sites for unsolicited applications under the open-door policy.

American energy policy is divided between federal and state jurisdictions, with the Department of the Interior (DOI) overseeing the regulatory framework for offshore wind power and the Bureau of Ocean Energy Management (BOEM) managing the implementation of federal policies, including leasing of seabed, and permitting for OSW projects in federal waters. Similar to the Danish authorities, BOEM is also open to unsolicited applications, but so far there are no instances of an unsolicited application resulting in a commercial-scale lease without an auction.

South Korea is an example of open-door policy implemented fully for commercial projects. Developers have rushed to secure sites in this emerging OSW market by deploying buoys to gather data from the desired sites, and South Korea has thus successfully attracted interest with an open-door policy.

3.3.2 Site-specific approaches

The site-specific approach, where a government authority chooses specific sites to be auctioned off to developers, is the most widespread.

The advantage of this approach is the transparency it provides for planning purposes: It becomes possible for the relevant authorities to join in on the siting process and makes it easier to ensure proper grid connectivity and predict overall system costs. Furthermore, the central government will likely have a better overview of possible stakeholder-issues and can choose sites that will cause the least opposition while still having adequate wind resources. The downside of this approach is the degree of investment needed from the government, as the government effectively takes on the risks associated with early-stage siting, such as wasting time and money investigating sites that turn out to not be viable etc.

Most offshore wind projects in Denmark get seabed rights by winning site-specific tenders. The DEA carries out a wide range of surveys prior to selecting a site for tendering. The investigations are part of a thorough screening process managed by a spatial planning committee and overseen by the DEA.

The committee consists of government authorities responsible for protecting the environment, safety at sea and navigation, offshore resources extraction, visual interests, and grid transmission conditions as well as industry experts in turbine, foundation, and grid technologies.

The committee collates geographic information system (GIS)-maps from the different authorities on top of each other to determine where there is ocean space free of pre-reserved areas or activities that will limit the possibilities of offshore wind development. The free or “empty” areas are evaluated based on wind resources and estimated costs of establishing offshore wind in the area, and public hearings are carried out to adjust the plans according to stakeholder concerns. The areas deemed suitable at the end of this process are reserved for offshore wind.

In 2007 the committee identified areas of 4.2 GW capacity, and in 2012 a further 15 near-shore areas were identified. As part of the Danish parliament’s Energy Agreement from 2018, new screenings were undertaken to determine areas suitable for installing an extra 10 GW.

Similarly, BOEM in the U.S. puts up leases for specific sites after choosing the sites from its designated Wind Energy Areas in collaboration with multiple federal and state level government agencies, apart from stakeholders such as indigenous groups or fisheries.

In Germany too, a site-specific approach is used. The Federal Maritime and Hydrographic Agency is responsible for identifying offshore sites. The agency first sets up a “Site Development Plan” which determines location and realization periods for specific sites. Then the agency investigates the sites to provide bidders with all the information required in the following tender.

3.3.3 Zoning

In markets with a zoning policy, the government points out certain zones within which developers may propose more specific sites.

In the U.K., the Crown Estate’s Round 4 tender process included bidder led site selection within four available Bidding Areas (Dogger Bank Bidding Area, Eastern Regions Bidding Area, South East Bidding Area and Northern Wales and Irish Sea Bidding Area) (Hogan Lovells, 2020).

These Bidding Areas constitutes zones, and their use combines upsides and downsides from both open-door policies and site-specific approaches. In the U.K. version, preliminary site investigations carried out by the government are very limited, so the developers still have to do a lot of groundwork surveying the sites, meaning the U.K. zoning approach places almost as much risk on the developers as an open-door policy.

3.3.4 Studies during the development phases

The goal of conducting publicly funded studies is to provide decision makers such as regulators and policy makers – but also developers, investors, and the public – with an assessment of a given geographic area, advancing the public dialogue about the potential for offshore wind energy.

In the early development phase, the following topics are part of the initial constraint mapping and siting process:

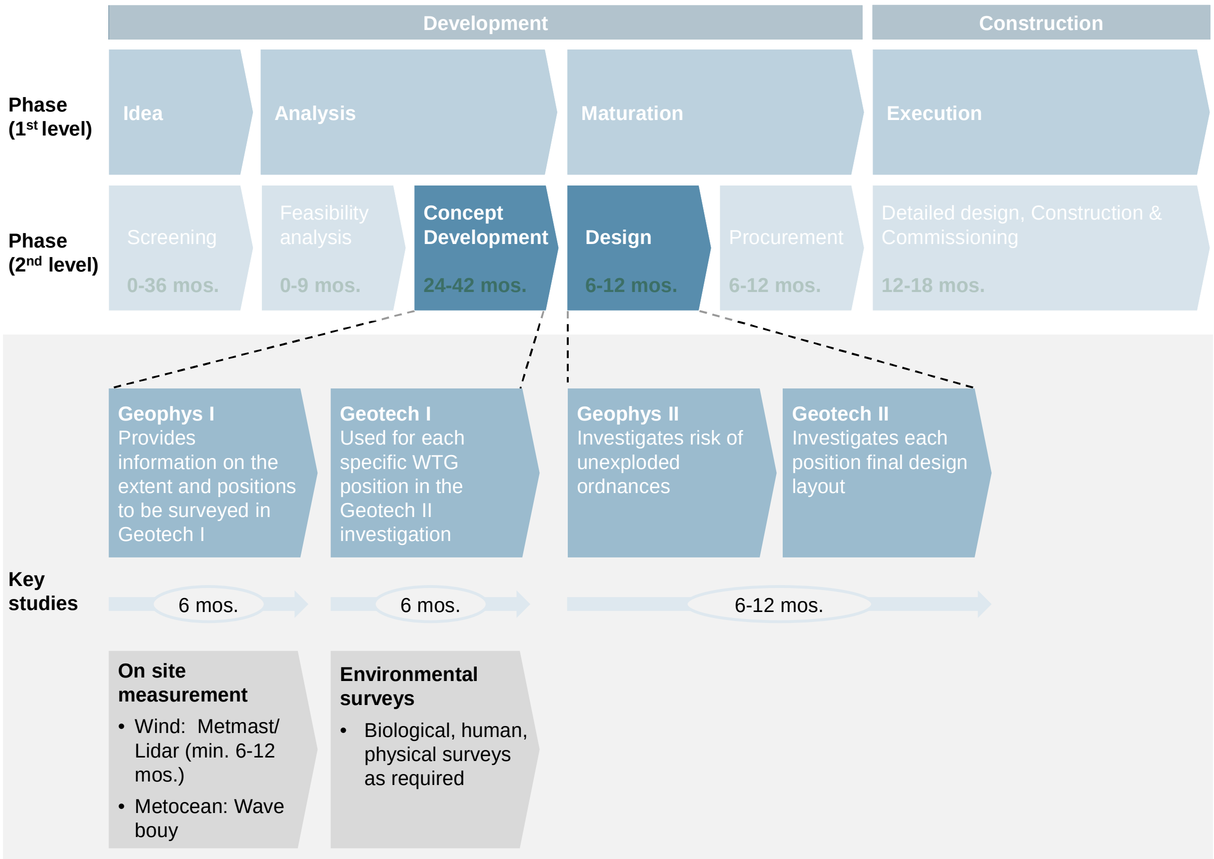
- Realistic offshore location options for an offshore wind farm, considering ocean users and stakeholders
- Energy production potential
- Wind turbine and foundation technology suitability, design and constructability
- Proximity to major ports and grid interconnection points.

This phase relies largely on gathering existing data. To initiate the siting process, historical metocean information is key, including models of wind and waves as well as bathymetry and environmental data.

When existing data has been collected and modelled, focus is on accurately estimating the long-term energy production. To ensure that it is a predictable investment, a minimum of 6-months to one-year of on-site metocean measurements are needed to fully characterize conditions across the entire year and changing seasons (Truepower, 2015).

Comprehensive geophysical and geotechnical investigations are critical to ensure that an offshore wind project can be executed and to estimate the associated costs. At a general level, geophysical and geotechnical surveys verify that it is possible to construct a wind farm at the given site. It ensures positions used are optimal given the soil conditions, and that foundations and cable routes are optimised.

Figure 11: Key studies in pre-development and development phases necessary for Environmental Impact Assessment approval and final design



High-level initial marine planning and siting: The U.S. and U.K.

In the U.S., sites for offshore wind energy in federal waters have been identified in a BOEM-led multi-agency collaboration process. Areas attractive for offshore wind development, called Wind Energy Areas, are identified in collaboration with state-level authorities and in consideration of various constraints such as protecting important viewsheds, sensitive habitats and resources and minimizing space use conflicts with activities such as military operations, shipping and fishing. Studies are made available to the public.

Next, BOEM initiates a Call for Information and Nominations to obtain nominations from companies interested in commercial wind energy leases within the proposed wind energy area(s). In parallel BOEM facilitates stakeholder engagement while continuing data collection and studies in the inter-governmental task force including state and federal agencies, industry, academic institutions, and NGOs (BOEM, 2021).

Similarly, The Crown Estate in the U.K. undertakes work to de-risk the environmental and consenting process through targeted research, with industry and non-profit organizations, on issues such as birds, collision risk for vessels and helped managed the interaction between the offshore wind industry and telecoms sectors (GWEC, 2014).

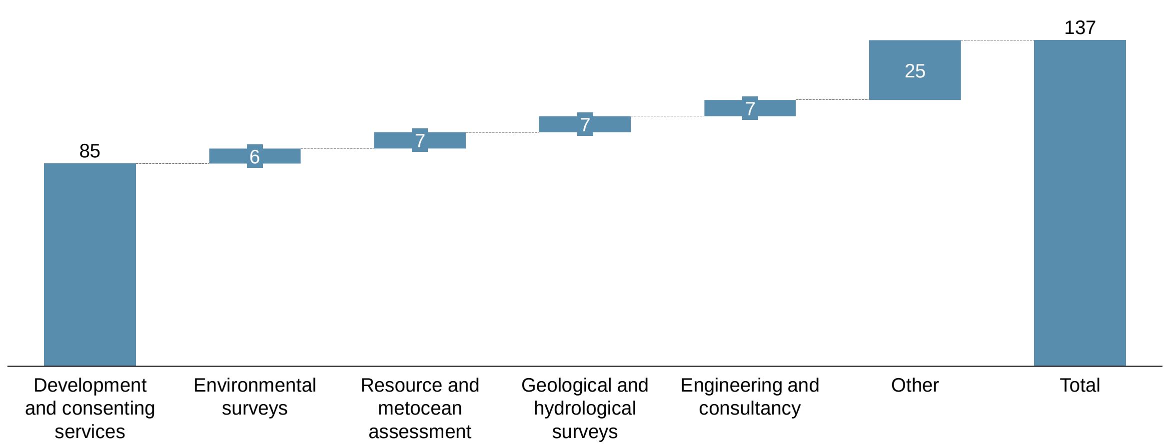
Comprehensive de-risking studies: Denmark and Germany

In Germany, the Federal Maritime and Hydrographic Agency (BSH) identifies potential offshore wind areas in collaboration with the Federal Network Agency (BnetzA). Corridors for cable routes and transmission platforms are also identified and listed in the maritime spatial development plan (Girard, 2019).

In Denmark, the government takes the de-risking of sites a step further as it leads a range of pre-auction investigations into ocean currents, wind speeds, marine life, other ocean users, grid connection and more. These investigations, including the initial geophysical investigation (Geophys I) and Initial investigation of geotechnical conditions to be used for each specific WTG position (Geotech I), are carried out by the TSO and made publicly available prior to the tendering process. The results of these pre-investigations enable the developers to submit qualified and realistic bids and lowers risk related to permitting timeline and costs (GWEC, 2014).

The common development activities and cost breakdown is illustrated in **Figure 12**.

Figure 12: Development activities and costs



Note: Numbers have been modified from ORE Catapult UK

3.4 Auction design and financial support: FiTs or CfDs preferred mechanisms

Figure 13: Auction design and financial support in selected jurisdictions

Denmark

- Concession payments (Old): Fixed price/kWh based on CfD for 50.000 full-load-hours
- New: CfD-based price premium (20-years) with payment ceiling

Germany

- Offtake criteria: price, system integration
- 20 years CfD: If electricity prices are lower than the agreed level of support, the difference is paid

United Kingdom

- Auction criteria: price, supply chain plan, grid connection
- 15 years CfD: The difference between the agreed support level and an index of the wholesale market price

United States

- State level: ORECs and/or PPAs awarded for 20-years through competitive auctions
- Federal level: ITC of 30%

Across markets globally, two main financial support models are used to stimule offshore wind:

1. Feed-in-Tariffs (FiTs), Feed-in-Premiums (FiPs)/Contracts for Difference (CfDs)
2. Renewable Energy Certificates (RECs) to meet RPS requirements

Both are mechanisms implemented by a legislative body to promote the production of electricity from renewable energy resources.

A look at experiences across jurisdictions shows that:

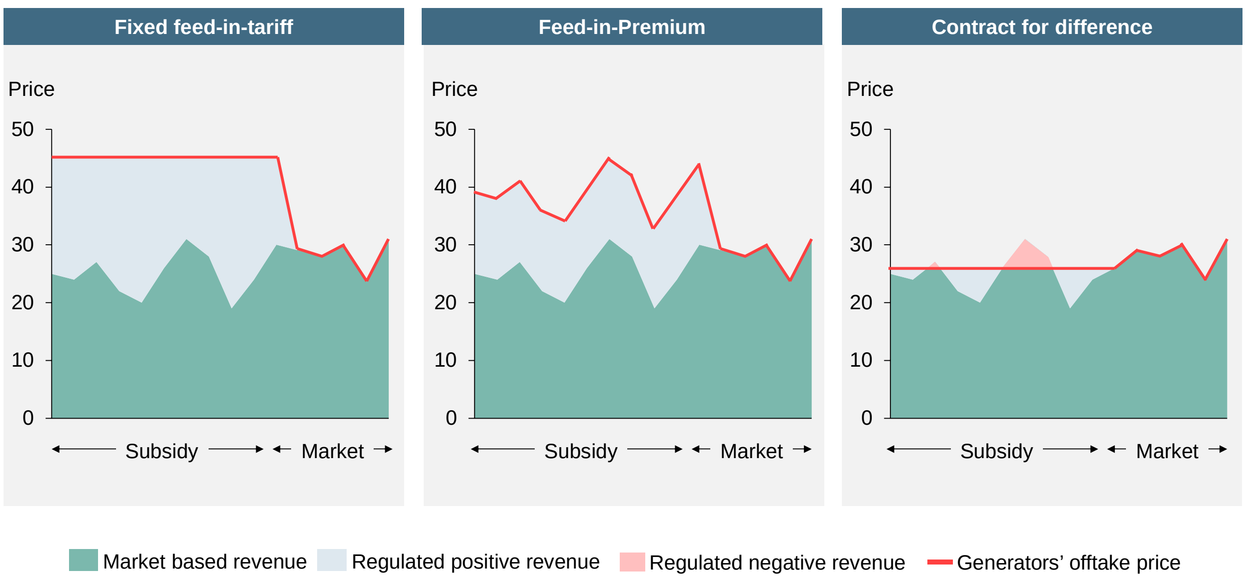
- FiTs offer the greatest financial security and ease initial offshore wind build-out, as investors and banks are assured by a government-guaranteed fixed-price revenue stream that is completely untethered to market prices
- FiPs/CfDs offer almost the same level of financial security as FiTs, depending on the design of the contract. In a hybrid, two-sided CfD there is a small exposure to market prices, making for a little less security in case of falling market prices. This exposure is thought to encourage smarter energy production compared to FiT-schemes
- RECs offer less financial security but encourages price competition, potentially leading to more efficient and cheaper green energy
- All models of compensation can be regulated through a power purchase agreement (PPA), and the difference between them shrinks if a REC scheme is implemented through a long-term, fixed-price PPA
- Overall, the industry prefers FiT or CfD models but will also go for attractive REC-models with fixed price PPAs

- RECs that are freely traded in an uncertain market offer the least amount of financial security
- All models can be combined with competitive lease auctions to ensure lowest possible electricity prices

3.4.1 Introduction to FiTs and FiPs/CfDs

FiTs and FiPs/CfDs are price-based schemes generally seen in markets with a high degree of government involvement, as they typically entail a subscription deal, where the government or a regulated utility buys renewable energy from producers at a set price for a set number of years, usually 15 or 20 years.

Figure 14: Comparison of fixed FiT, FiP and CfD mechanisms



In a classic FiT scheme, the offtaker pays the generator a fixed price per MWh of electricity regardless of how much or little energy is produced and regardless of what the electricity would sell for in the free market. The price per MWh can be set through regulator order, in which case it will be based on the expectations for how costly it will be to generate the energy, or the price can be determined through competitive bidding.

The FiT scheme is the most reassuring to offshore wind developers on paper, as all energy produced for the initial set period is sure to be bought at a guaranteed price. The total amount of power the state is willing to purchase for the FiT price can be regulated through the offtake agreement.

The high level of revenue certainty leads to lower financing costs since the government-guaranteed FiT-price is usually high enough to ensure a satisfactory revenue stream even in cases of high LCOEs. All of this contributes to lowering the perceived risk of investing in offshore wind and may be the reason why many of the mature markets started out using a FiT scheme, including for instance Germany, Denmark and the Netherlands.

The downside of the FiT system is the risk of not encouraging development (of technology, best practice, efficiency etc.) through continuous price competition – especially in immature markets, where the FiT rate has often been set by regulatory order instead of being determined in a competitive auction.

FiPs entail that the government pays a premium on top of market electricity prices. The premium can be fixed or sliding. A fixed premium means that the premium paid stays the same no matter how electricity prices develop, while a sliding premium is usually tied to electricity prices in some way.

CfDs are a kind of sliding premium FiPs, where the developer and the state enter into an agreement for the offshore wind farm to supply energy for a specified price. The price level is determined through a competitive bidding process with the lowest offered price level wins. Under the CfD, the OSW generator sells the produced electricity at market price and then receives a top-up from the government if the market price is lower than the agreed upon price. This is the model used by Germany.

If the CfD is two-sided, the generator must pay the government back in case of electricity prices being higher than the agreed upon level of support. Two-sided CfDs are utilized by a rising number of jurisdictions including the U.K., Denmark, Poland, France, Ireland and Lithuania (WindEurope, 2021).

CfDs can also be further customized to encourage the generator to consider the market when designing the production. In Denmark, the authorities have recently implemented what they refer to as a hybrid, two-sided CfD for the Thor offshore wind farm (DEA, 2020). The market price that the generator is compensated according to, is calculated as the average of the market prices the preceding calendar year, meaning that the price premium awarded in for instance the year 2029 will be calculated as the difference between the bid price and the average electricity price of 2028. This set-up exposed the generator to a small risk, if market prices in 2029 were to fall significantly compared to the prices in 2028, as the generator will then not be compensated up to the level of the bid price. This small risk is thought to incentivize smarter electricity production, as the generator will benefit from adapting production to market demand (DEA, 2020).

3.4.2 Introduction to RECs

RECs are quantity-based schemes typically seen in more liberal markets. Theoretically they are entities to be sold and traded in a free market.

RECs are used in jurisdictions where an RPS requires suppliers of electricity to procure a certain percentage of their power from renewable sources. The RPS thus sets a quantity of renewable energy to be procured and in theory leaves it to the market to determine how best to supply the needed power.

To ensure that the electricity suppliers can be held accountable for the amount of renewable energy they procure, RECs are issued to renewable energy producers. 1 MWh generally translates to one REC, though this can vary, as politicians might want to encourage specific kinds of renewable energy by awarding them more RECs per MWh. The renewable energy producers then sell the RECs as entities separately from the power they represent. The power suppliers must buy RECs from the generators to fulfill their RPS-requirements.

In theory, the RPS/RECs system could lead to cheaper renewable energy than the FiT system, as the cheapest renewable energy producers can charge lower prices for RECs and thus will be better able to sell their RECs in a free market than more expensive ones. The downside would be the risk of only the cheapest renewable energy sources being developed, leading to a homogenous energy-mix with less energy security. South Korea is an example of a jurisdiction that has experienced some challenges after introducing RECs, with uncertain market prices and development of certain energy sources over others (Lee & Ko, 2020).

However, RECs are not necessarily traded in a free market. Often, both RECs and energy from an offshore wind project are sold to a specific offtaker under a PPA with a fixed price. This significantly upgrades the schemes' level of financial security while downplaying the level of competition, thus bringing REC schemes close to FiT and FiP/CfD schemes in terms of attractiveness to investors.

This model is for instance used in U.S. East Coast states. The RPS/REC model in the U.S. East Coast states is in effect very close to European style FiT and CfD-models. The selling and buying of offshore wind power and RECs in these states is often managed through a fixed-price PPA, meaning that the generator sells either both power and RECs together or separately at a guaranteed price to the same off-taker for 20 years or similar. In effect this is a FiT. The exception to the rule about fixed-price PPAs is New York's model, where the price is not fixed but sliding – determined relative to market prices. This is in effect very much like a CfD.

Thus, the RECs/RPS models in the U.S. can be said to emulate the European-style FiTs and CfDs.

Figure 15: Simplified comparison of main schemes for renumeration

	Feed-in-Tariff (FiTs) and Contract for Difference concepts (CfDs)	Renewable Energy Certificates (RECs)
General characteristics	• Price-based • High degree of government involvement	• Quantity-based • Lower degree of government involvement
Advantages	✓ High financial security leading to lower financing costs for developers, lower bids and ultimately lower electricity prices ✓ For FiTs: Dependable budgeting for the state due to fixed costs towards support	✓ Price competition encourages innovation if RECs are traded in a free market ✓ Low initial costs for the government to implement
Disadvantages	× More expensive for the government up-front × After the initial competitive auction, there is no further price competition	× Less financial security for developers, leading to higher financing costs and potentially more expensive electricity – or a lack of interest in building OSW at all

- Both models of compensation can be regulated through a PPA, and the difference between them shrinks if RECs and their associated power are sold at a fixed price for 15+ years through a PPA
- Both can be combined with competitive lease auctions

3.5 Permitting regimes: One-stop-shops ease build-out

The most important lesson learned in mature markets is that the fewer government agencies the developer needs to consult with to obtain relevant permits, the better.

Several of the jurisdictions examined in this report aim for the one-stop-shop approach where the developer only has to interface with one government agency, and all jurisdictions try to at least limit the number of agencies the developer needs to consult.

Figure 16: Permitting regime and key permits across jurisdictions

Denmark

One authority, Danish Energy Agency (DEA), coordinates across permitting bodies; One-stop-shop

- License to carry out preliminary investigations
- License for construction
- License for the utilization of energy
- License to produce electricity

Germany

Marine regulator, BSH, has leading role, supplying most permits in the form of a "planning approval"

- Planning approval which includes all required public permits (BSH)
- Grid connection agreement (TSO)

United Kingdom

The DCO, granted by BEIS, is an umbrella permit that covers a collection of needed consents

- Development consent order (BEIS)
- A generation license (Ofgem)
- Agreement for Lease, Transmission Agreement for Lease, Transmission Lease (corridor for offshore transmission) (TCE)

United States

BOEM oversees key permits in federal waters, but OSW still need consent from other authorities. Process in state waters uncertain

- Site Assessment Plan (SAP)
- Construction and Operation Plan (COP)
- Environmental Impact Statement (EIS) issued (approval)

3.5.1 The most comprehensive one-stop-shop: Denmark

In Denmark, all offshore wind permits are granted by the DEA, which functions as a very comprehensive one-stop-shop. The permits include a permit to perform preliminary site investigations for the specific project, mainly into turbine locations. Granted for one year. After this the developer must submit an EIA and a specific project proposal. If the above EIA and proposal are approved, a construction permit is issued. Once construction is completed, a permit for utilizing offshore wind energy is granted, provided the constructed project lives up to the terms that were established in the license for construction. These terms include Labour and Social Clauses that aim to ensure that workers on the project must live up to Danish standard. Finally, a permit for producing electricity is issued.

The only responsibilities of the developer are to undertake project-specific Impact Assessments in accordance with European and Danish legislation. The developer needs to carry out a Strategic Environmental Assessment (SEA) of the plans; an Environmental Impact Assessment of the specific project offshore – meaning the wind turbines and foundations, offshore substations, and export cables until landfall – and assessments regarding impact on the Habitats Directive (Natura 2000).

Parts of the project developed on land falls outside of the developer's responsibility. The TSO in collaboration with municipalities will do an EIA of these parts; from the landfall to the onshore substations and the 400 kV transmission grid.

Finally, the developer must also negotiate settlements with private landowners and fishermen, if the project needs to lay cables on private lands or if the project will disrupt commercial fishing. Compensations for fishermen are somewhat regulated by the Danish Fisheries Act and must be based on documented loss of income. If private landowners refuse to allow cables to be laid despite offers of compensation, the developer can apply for permission to expropriate the land under the Electricity Safety Act.

Apart from the expectations for fisheries and landowners, the permits issued by DEA cover nearly all aspects of the project and contain terms and conditions from relevant authorities (Ministry of Defense, Danish Nature Agency and many more), who were consulted long before the site in question was even tendered. For this reason, the Danish permitting one-stop-shop is among the most efficient in the world.

3.5.2 Less comprehensive one-stop-shops: Germany and the U.S.

While BOEM in the U.S. works as a focal point for the leasing and permitting process, it is not a one-stop-shop to the extent that the DEA is, as permits are still required from other sources. After having been granted a lease by BOEM, developers must submit a Site Assessment Plan (SAP) and Construction and Operation Plan (COP) to BOEM, and once the COP has been approved, construction can begin. Thus, BOEM is responsible for the main permits.

But apart from these, permits are needed from the U.S. Coast Guard (permit for use of navigational lighting), United States Army Corps of Engineers (permit for subsea cables under the Clean Water Act and permits for air quality and pollution prevention), National Oceanic and Atmospheric Administration (Incidental Take or Harassment under the Marine Mammal Protection Act, Endangered Species Act, Migratory Bird Treaty Act, the Bald and Golden Eagle Protection Act, and the Magnuson-Stevens Fishery Conservation and Management Act) and not least a variety of state level agencies (NYSERDA, Permitting and Approvals, 2020).

Similarly, while the German authorities altered their permitting regime in late 2020 under the Offshore Wind Energy Act (Windenergie-auf-See-Gesetz) to streamline the process, it is still not as straightforward as the Danish model. For OSW farms commissioned after 31st December 2020, the Federal Maritime and Hydrographic Agency (BSH) will thus be the authority which handles most permits. The main permit required is a “planning approval”, which is granted by the BSH. A planning approval includes all required public permits for an OWF (Hogan Lovells, 2020).

However, even though the process has been sought simplified and most permits are covered by the planning approval, the permitting process in Germany has still been called a main bottleneck by industry representatives. This is due to the developer needing to supply much information and the risk of permits being challenged in court, a possibility the process allows for (Windeurope, 2021).

The UK also does not have a one stop shop, though it has tried to limit the number of permits needed. Authorities issuing permits include: Ofgem, the Department for Environment, Food and Rural Affairs (DEFRA), the Planning Inspectorate, Marine Management Organisation (MMO), Ministry of Defense and more (Hogan Lovells, 2020).

3.6 Grid connection

The regulatory regime for connecting an offshore wind project to the onshore grid, including scope, planning, construction and operations, varies substantially across jurisdictions.

Figure 17: Grid connection in selected jurisdictions

Denmark

- Going from TSO-build to Generator-build transmission (next OSW tender)

Germany

- TSO is required to fund all offshore wind grid connection works to an offshore connection point (offshore substation)

United Kingdom

- Developers fund and construct transmission infrastructure but required to sell to third party ("OFTO")
- Costs are socialized post construction when sold off

United States

- Generator-build transmission (push to investigate state-led solution)

Jurisdictions such as Germany, Denmark, and the Netherlands can be said to have a 'Transmission System Operator (TSO)-led' governance model, wherein a state-appointed TSO has responsibility for providing the transmission system for offshore wind projects to be connected to.

An important characteristic of the TSO-model is that timely establishment of grid connection is guaranteed by the authorities. The costs of establishing connection from the offshore wind farm to the electricity grid are covered by the TSO, which then later socializes the costs among consumers. This model decreases investor uncertainty significantly, as grid connection is an important part of the project's economic timeline. The developer's only responsibility is to connect the individual turbines to the grid, and if the connection of turbines does not follow the schedule laid out in the tendering agreement, the developer must pay fines (S. Ropenus & H. Klinge Jacobsen).

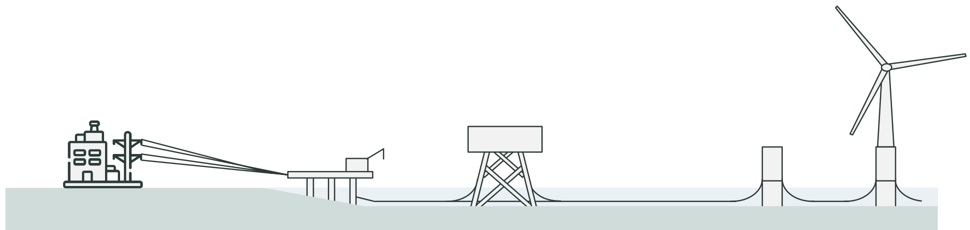
In Denmark, the TSO also holds the responsibility for any necessary reinforcement of the underlying grid. This model promotes wind power by making the necessary grid available to the offshore wind farm with no risk and costs to the generator (Sørensen, 2015). In U.S. East Coast states, this cost is allocated to the generator based on grid capacity studies conducted by the grid owner.

In Germany, the TSO is responsible for delivering and operating the offshore transmission system to a cluster of projects. The TSO providers, TenneT and 50Hertz, are not exposed to competition. In the past, TenneT has not been able to deliver the offshore substation and transmission to shore for connecting the offshore wind farm when scheduled, with an average delay of one year delay seen so far. This has led to significant risk for the generator as the compensation available does not cover the entire production loss (Girard, 2019).

In the other typical model, called the ‘Generator Model’, the offshore wind project developer is responsible for design and construction of the transmission system. The Generator Model is seen in for instance U.S. East Coast states and Taiwan (Brard, 2017). For the next Danish offshore wind tender in late 2021, the Generator Model will also apply. The rationale behind this shift to including the grid connection in the tender is to stimulate critical innovation in design, construction, and operation of the grid connection, and ultimately to lower total costs of the entire offshore wind farm project (Danish Energy Agency, 2020).

The UK stands perhaps as the most unique governance model for offshore transmission with its so-called Offshore Transmission Owner (OFTO) regime. Its unique feature is that the OSW project developer can choose to have the offshore transmission system provided in one of two ways: the generator-led model and the TSO-led model (Ofgem, 2018). To date, all projects have chosen the generator-led model.

Figure 18: Country specific variations for transmission assets of an OWF



	Onshore substation	Export cables	Offshore substation	Array cables	Sub-structure	Wind turbine generators
UK	Developer[1]	Developer[1]	Developer[1]	Developer		
Germany	TSO[2] (TenneT/50Hertz)	TSO (TenneT/50Hertz)	HVDC (DolWin): TSO HVAC: Developer	Developer		
Denmark	TSO (Energinet[3])	TSO (Energinet[3])	TSO (Energinet[3])	Developer		
United States	Developer	Developer	Developer	Developer		

1) Assets required to be divested to an Offshore Transmission Owner (OFTO) following commissioning
2) Transmission System Operator (TSO)
3) For next OSW project, Thor Offshore Wind Park, the Developer will be responsible for and own the transmission assets (Onshore substation, Export Cables and the Offshore substation)

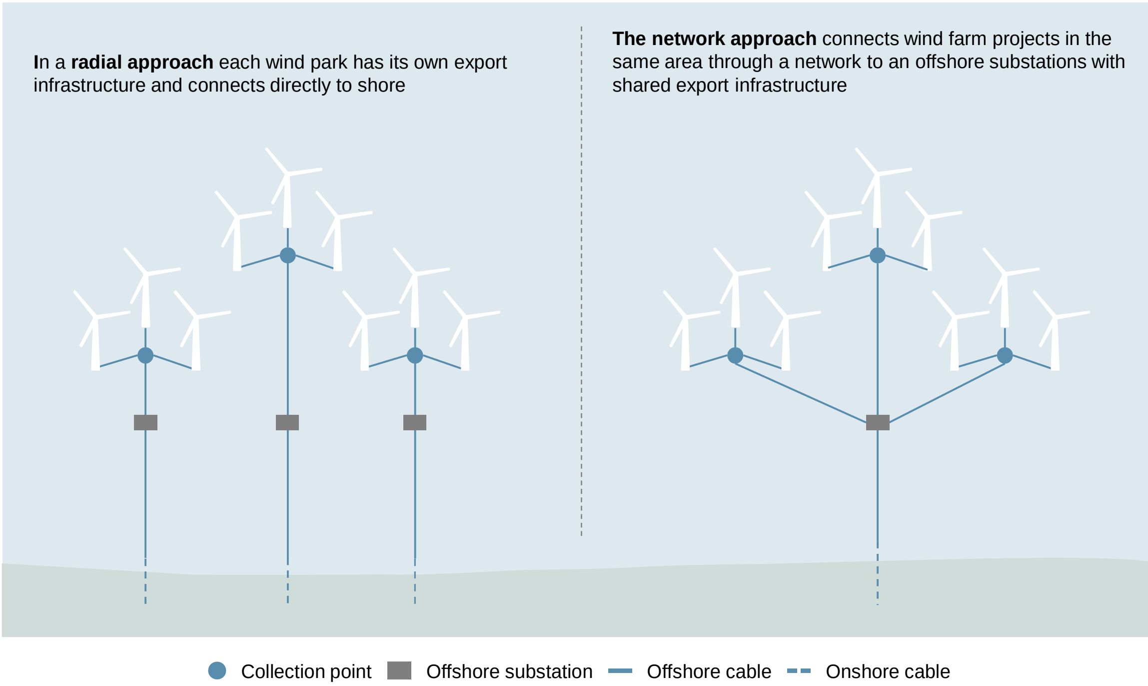
Two overall approaches to connecting the offshore wind farm to the onshore grid exist:

1. Transmission facilities are individually built to support single projects (radial approach)
2. Transmission facilities are developed via a shared transmission line and offshore substation to accommodate multiple projects (network approach)

Denmark, the U.K. and the U.S. states all have radial grid connections for their offshore wind projects. Germany is the only country to have adopted a network-based grid model (NYPA, 2019).

The radial transmission approach has been widely applied as it is more simple and less risky to the timetable of offshore wind projects. The network-based transmission approach offers potential economies of scale but at the cost of uncertainty and potential delay as seen in Germany. The U.K. government has recently announced that a network-based transmission approach will be implemented to meet an urgent need for better coordination of cable agreements, as cable crossing offshore and landfall as well as onshore cable route approvals are costly and inefficient for developers and impact on communities increase (Renews, 2021). The same approach is being discussed in New York as direct grid connection from the offshore wind farm to onshore grid points are restricted (Brattle Group, 2020).

Figure 19: Offshore transmission approaches



3.7 Policies promoting system integration and hybrid solutions

When a country starts to integrate a significant capacity of variable power sources such as commercial-scale offshore wind power into the overall power grid and system, several considerations should be made. Long-term planning and timely investments in the power grid and system that support the future expected energy mix are key (Sørensen, 2015). A balanced and well-functioning power market is a fundamental condition.

In recent years, energy system integration promotion in relation to offshore wind build-out has been applied in conjunction with offshore wind farm auctions. Massachusetts' first offshore wind tender in 2017 had a soft requirement to offer a battery storage solution in combination with the offshore wind farm; however, battery storage was not included in the winning bid (Orsted, 2017).

In July 2020, the Hollandse Kust North zone tender in the Netherlands was awarded to a consortium of Shell and the Dutch utility Eneco, as the winning bid included several elements of system integration and storage. The power from the offshore wind project will be used to create a renewable hydrogen hub in the Port of Rotterdam with an electrolyser capacity of circa 200 MW. In addition, the winning bid includes a short-term battery storage solution and a floating solar park. Both will contribute to ensuring a stable power supply (Windeurope, 2020).

In Germany and the Netherlands, the tender system for recent offshore wind projects requires bidders to submit zero bids, meaning no public funding on top of the wholesale market revenues. The bids are instead ranked based on qualitative criteria which then becomes firm requirements, including system integration solutions.

3.8 Promotion of domestic supply chain & skills development

Localization of the socio-economic benefits of offshore wind development is a complex subject for which policy makers must consider tradeoffs such as future buildout in the region, cost, availability industrial capabilities and logistical limitations of deployment (IRENA, 2018). On this account, it is common for jurisdictions to establish special bodies or task forces to manage such efforts, one example being the United Kingdom's Green Jobs Taskforce. Its aim is to focus on the immediate and longer-term challenges of delivering skilled workers for the U.K.'s transition to net zero including:

- Ensuring we have the immediate skills needed for building back greener, such as in offshore wind
- Developing a long-term plan that charts out the skills needed to help deliver a net zero economy
- Ensuring good quality green jobs and a diverse workforce
- Supporting workers in high carbon transitioning sectors, like oil and gas, to retrain in new green technologies (UK government, 2020)

With regards to specific models for securing local economic benefits, they are numerous and may be applied in parallel to achieve a desired outcome. A selection of benefit models which exist in the U.K. are presented in **Figure 20** below.

Figure 20: Selected models for promotion of economic benefits in the UK

	Description of mechanism	Merits
Direct local supply chain development	• Projects may have firm or soft targets for utilization of local supply chain across the project life-cycle	• Provides clear guidance of state expectations toward the project developer • Ensures desired outcome • May target specific supply chain elements
Indirect local supply chain benefits	• Non-mandated creation of jobs through regional supply chain involving local businesses and infrastructure • Some developers highlight the significance of indirect benefits in addition to community benefit arrangements while others only emphasize the role of indirect benefits	• Developers can steer and prioritize the engagement of local business • Benefits are spread more widely
Community funds	• Developers pay into a particular fund arranged around an offshore wind project • Fund may be administered by the developer, authority or community • Mechanisms of funds are usually established in consultation with affected and benefiting communities	• Easy for developer to arrange through 3rd party fund managers • Possibility of administration of funds through community groups allowing community to decide how funds are spent
Apprentice-ships and studentships	• Benefit schemes that provide funding for education as well as skills and training by providing funding • Commonly connected to required skills in the offshore wind sector or green transition	• Development of knowledge in the local region
Educational programmes	• Presentations and workshops in schools or colleges • Raising awareness of climate change, • sustainability, environment, and renewables • Encouraging and providing specific skills and knowledge for careers in the renewable energy sector	• Useful for continuing dialogue with local communities • Awareness raising • Comparatively easy to establish and implement

3.8.1 Local supply-chain development: Challenging if conditions are not competitive

If the desire is to build a manufacturing sector locally that can supply all key components for an offshore wind farm, it requires clear long-term build-out targets of a vast volume making it attractive for international manufactures to make significant investments in manufacturing facilities locally and the required transfer of skills.

The U.K. has been an example where over a period of roughly ten years, industry is now well progressed in developing competitive local capabilities across wind turbine component production, power transmission cables and foundation fabrication. Very recent examples include GE's announcement of a blade factory at Teeside, and Global Energy Group's planned tower and monopile factory being constructed in Nigg (GE, 2021) (Recharge, 2020). Despite some earlier challenges with re-purposing oil and gas fabrication facilities for foundation fabrication (Bifab, Fife), the U.K.'s ability to attract substantial supply chain investment is considered an industry success case which has delivered substantial local benefits (BBC, 2020) (RenewableUK, 2020).

Looking to the emerging U.S. industry, there has been seen, amongst others, to be site surveys and investigation activities and related offshore marine services, blue-collar assembly works in ports, support vessels and manpower for construction phase, operations and maintenance port base, vessels and services for the 30 years lifetime of the OWF. At a point where there is sufficient project capacity and uninterrupted pipeline established, then suppliers may justify investment in local fabrication on account of savings in logistics. There are a number of recent initiatives towards localization of component fabrication; a local turbine tower and transition piece factory at Port of Albany, New York, and further, a number of turbine suppliers have signaled that further component fabrication opportunities will eventually come on account of the substantial OSW capacity planned (Welcon Marmen, 2020).

In very early stages of an emerging offshore wind market, instead of having a sole focus on building a domestic capital-intensive supply chain, a lower risk approach can be to promote opportunities within the existing industrial base. Eventual localization of capital-intensive components would then become feasible if there is sufficient capacity such that logistical cost of transport from other regions becomes prohibitive to competitiveness.

3.9 Conclusion: Lessons learned from other jurisdictions

In summary, the following take-aways can be presented from leading as well as from emerging offshore wind markets:

- In general, official longsighted targets in GW for offshore wind capacity increases developer's interest and willingness to invest, as offshore wind projects are long-term investments with large payments up front and a long horizon for payback. Short-term targets should be realistic and supported by a roadmap, while long-term targets should be more ambitious, but still realistic
- The site-specific approach to siting and seabed leasing, where a government authority chooses specific sites to be auctioned off to developers based on maritime spatial planning, is the most widespread. Modelling of existing metocean and bathymetry data, and de-risking environmental impact studies are government-led in most jurisdictions. Expertise and competence build-up in governments in new markets are often required
- Overall FiT and CfD schemes are the most assuring to investors and make for the most attractive set-up. FiTs or CfDs are the preferred option of mature markets in Europe, and the East Coast states in the U.S. can be said to emulate these models to achieve similar levels of project bankability

- One-stop-shop concepts of one authority coordinating key permits make for an efficient process with less delays and lower market risk perception
- Generator-build grid connection model is the preferred approach from offshore wind developers' perspective, significantly reducing delay and interface risks. The radial transmission approach – having one offshore transmission asset per project is widely used
- Recently, winning offshore wind bids in Europe have included several elements of system integration and storage
- Benefit models for promoting economic benefits is managed by special bodies or task forces. Efforts include direct and indirect supply chain development, community funds, apprenticeships, and educational programs.

4 Existing conditions in Nova Scotia

This section presents an overview of Nova Scotia's current energy situation and existing capabilities to support a potential offshore wind development build-out. Firstly, Nova Scotia's energy mix and demand is analyzed both in a historical context and looking towards 2050, and targets to phase out fossil fuels and replace with renewables are discussed. Then the specific offshore wind market drivers in Nova Scotia are assessed: Regional employment levels and industrial capabilities are considered, and the overall level of readiness for the Nova Scotia offshore wind supply chain. Essential infrastructure for offshore wind development, such as port conditions and maturity of transmission infrastructure is also assessed.

4.1 Current electricity mix and demand

The electricity generated within Nova Scotia to a large extent comes from combustible generation, using either non-renewable fuels such as coal, natural gas and petroleum, or biomass such as wood, spent pulping liquor, methane, municipal waste, and other waste (Statistics Canada, 2020a).

During 2020, electricity from combustible fuels accounted for 82% of total production. Onshore wind turbines and hydraulic turbines accounted for the remaining generation, contributing with 10% and 8%, respectively (Statistics Canada, 2020a).

The latest available data on electricity generation with a renewables and non-renewable split is from the report "Canada's Energy Future 2020" (EF2020). According to the report, Nova Scotia generated 8.9 terawatt hours (TWh) of electricity in 2018. Coal is the major source of domestic electricity in Nova Scotia. In 2018 it accounted for approximately 55% of total generation in the province. Looking back at 2005, coal was even more dominant, contributing over 70% of generation. Primarily renewables, driven by onshore wind build-out, and natural gas have been increasing since 2005. In 2018, approximately 26% of electricity production was from renewables.

EF2020 also presents two scenarios of potential outcomes for the electricity mix over the next three decades. These scenarios are the Evolving Scenario and the Reference Scenario:

Evolving Scenario: "(…) considers the impact of increasing action on climate change throughout the projection period. It builds upon current climate and energy policies with a hypothetical suite of future policy developments" (Canada Energy Regulator, 2020).

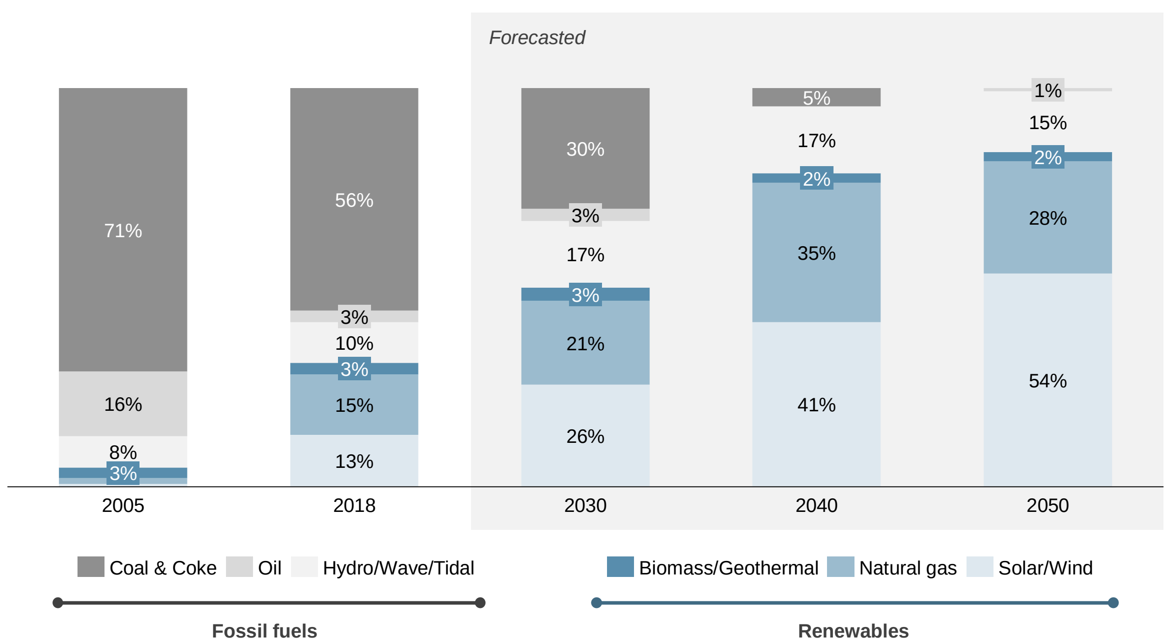
Reference Scenario: "(…) provides a baseline outlook with a moderate view of energy prices and economic growth, and climate and energy policies announced at the time of analysis" (Canada Energy Regulator, 2020).

In the Evolving Scenario fossil fuels will be gradually phased out in favor of renewable sources. By 2040, oil will be close to non-existing in the energy mix, and all coke and coal plants will be fully decommissioned by 2050. Renewables will replace retiring plants together with natural gas, up until 2040, from which point on the share of natural gas is projected to gradually go down. In an Evolving Scenario, renewables will account for 46%, 61% and 71% in 2030, 2040 and 2050, respectively. The category containing both solar and wind is estimated to account for approximately half of total generation in the province by 2050.

Recently, a new renewable target was announced by the new Premier Rankin. The target stipulates that Nova Scotia should have 80% of its electricity use to come from renewable sources by 2030.

Looking at overall energy demand in Nova Scotia, the levels have fallen close to 20% from 2005 to 2018 and is expected to fall going forward (Canada Energy Regulator, 2020). Overall energy demand comprises of electricity, natural gas, oil (gasoline and coal) and renewable fuels.

Figure 21: Electricity generated in 2005 and 2018 and forecasted generation in 2030, 2040 and 2050 by fuel source in an Evolving Scenario



Electricity production has declined since 2005 to 2018 by approximately 25%. At the same time, electricity generation is expected to increase 14-21% from 2018 towards 2050, in the reference and evolving scenario from in the EF2020 report.

The main source of electricity imports is coming from neighboring province of New Brunswick. A 350-megawatt capacity transmission line connects Nova Scotia with New Brunswick. In 2018, about 4% of generation was from imports.

The residential sector in Nova Scotia consumes the most electricity. Most of the residential electricity demand comes from highly populated areas around Halifax **(Figure 22)**.

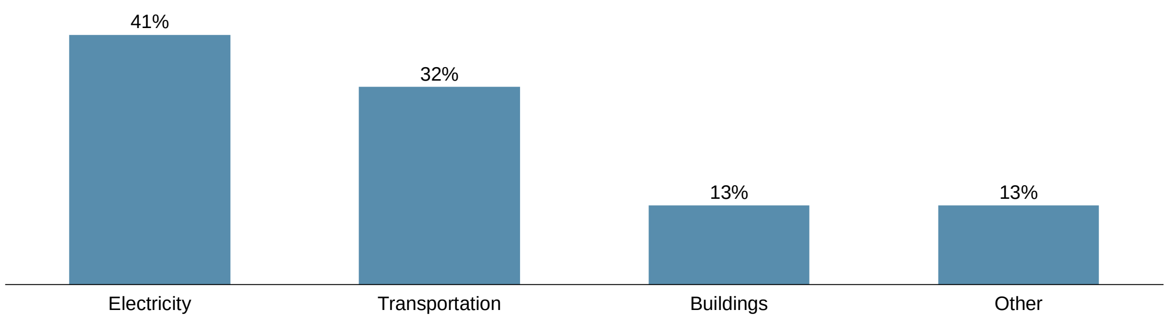
Figure 22: Map of Nova Scotia highlighting load centers based on populated areas

***Blue** - Small population center (population 1,000 to 29,999)*
***Red** - Large urban population center (population 100,000 or greater)*

As can be seen in **Figure 23,** by 2018 electricity generation accounted for most of the greenhouse gas (GHG) emissions in the province at 42%.

Hence it is a priority issue for Nova Scotia to transition electricity generation towards renewables to achieve a less emission. Offshore wind is one of the sources that could be relevant in this transition.

Figure 23: 2018 GHG) emissions by sector, *% of total emissions in Nova Scotia*[1]



4.2 Economic conditions

4.2.1 Labor situation

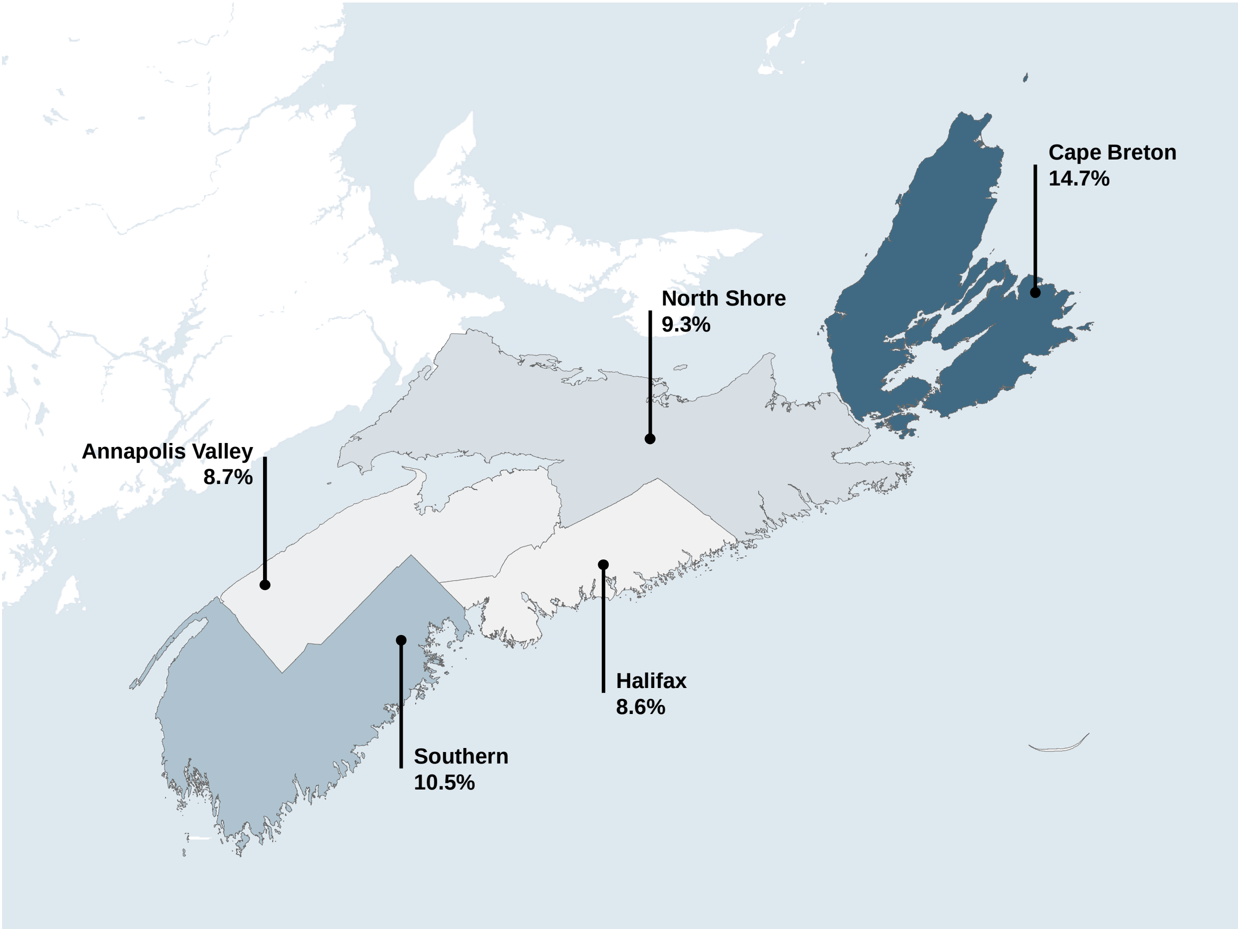
With a compounded global annual growth of more than 15%, the offshore wind industry will support a high demand for skilled workers in the future. The Norwegian energy intelligence firm Rystad Energy reported in 2021 that:

> *"Demand for offshore wind staff will triple by the end of the decade, surging to 868,000 full-time jobs from an estimated 297,000 in 2020"*
>
> (Rystad Energy, 2021).

Hence one of the possible positive impacts of an offshore wind build-out in Nova Scotia is direct and indirect employment and trade opportunities. An offshore wind build-out could create jobs in construction, installation, manufacturing, port and other marine services, and O&M. As can be seen in **Figure 24**, unemployment figures in 2020 ranged from 8.6% in Halifax to 14.7% in Cape Breton. In the same time period, the unemployment rate in Canada overall was 9.5%.

[1] Other includes: Heavy industry, Waste, Agriculture, Light Manufacturing, Oil & Gas, and Coal production

Figure 24: Map of Nova Scotia province with unemployment rates in 2020



4.2.2 Supply chain

Although offshore wind always creates jobs, the number of jobs created locally depends largely on the existing supply chain capabilities. If the right conditions do not exist, developers are likely to employ foreign supply chains to minimize project costs. Major components needed for offshore wind are turbines, foundations, on- and offshore cables and general electrical equipment such as generators and switchgears.

Existing supply chains in Europe and the one that will be developed on the U.S. Atlantic Coast will compete with Nova Scotia. On the other hand, the proximity of the U.S. offshore wind market and the fact of the Jones Act and tariffs on steel and aluminium may provide opportunities for Nova Scotia to support the U.S. offshore wind industry with ports, steel manufacturing services, engineering and marine services and vessels, which would make investments in the Nova Scotian supply chain more attractive due to the possibility of serving two markets.

In the fields of marine engineering, research and development, a diverse range of competencies already exist in Nova Scotia due to experience with marine defense and from the tidal energy sectors.

Nova Scotia is also home to numerous research institutions within ocean science, such as:

- The Bedford Institute of Oceanography (BIO)
- The Institute for Marine Biosciences (IMB)
- The Navy's Defense R&D Canada laboratory (DRDC)
- Centre for Ocean Ventures & Entrepreneurship

The research centers above have produced 450 PhD ocean scientists, which is the highest concentration in the world. Hence, Nova Scotia is often seen as the centre of oceanographic expertise (Nova Scotia Department of Energy and Mines, 2021).

In addition to this, The Fundy Ocean Research Centre for Energy (FORCE), Canada's leading research center for in-stream tidal energy, is located in the Bay of Fundy. FORCE is a center where electric infrastructure such as substations, offshore cables and access to environmental monitoring reports are made available for tidal developers. The idea is that the center should act like a catalyst for growth of the tidal industry in Canada.

Due to Nova Scotia's strong maritime industrial base from shipbuilding and the oil and gas sector, the option of utilizing local vessels for many functions related to offshore wind is feasible in Nova Scotia. This would not only be relevant for Canadian projects, but also possibly the larger U.S. market. Irving Shipbuilding Inc., based in Halifax, Nova Scotia, is the largest shipbuilding company in Canada and has built over 80% of the current naval fleet in Canada.

4.3 Infrastructure readiness

4.3.1 Ports

In a typical offshore wind project, ports close to the sites play a central role in all stages of an offshore wind farm's lifecycle. In the early planning phase, it handles installation of equipment that will facilitate development, such as wind measurement devices. Later it is involved in the installation stage, where the main port is usually called the 'base port' as it works as a base for the project. Components such as blades, nacelles, tower and foundations are transported to the base port, either by road or by sea and usually staged in the port, meaning that the base port needs to have storing capacity.

Components can also be fully or partly assembled in the port and some pre-commissioning can be done. This is mainly dependent on the technology used, as some floating concepts can be assembled on site. In the end of an offshore wind project's lifecycle, ports also play a role in the decommissioning phase.

For a first screening of potential ports in Nova Scotia, the World Port Index (WPI) has been used to identify main characteristics (WPI, 2021). Based on WPI, of the 17 ports in operation in Nova Scotia only the Port of Halifax is considered a large port, while the rest are either small or very small. As this classification of harbor size is "based on several applicable factors, including area, facilities and wharf space", it can give a good first indication of suitability for offshore wind needs (WPI, 2020). However, some specific port features that are required for offshore wind development are cargo depth, loading capacity, service-level, security and availability of equipment such as cranes.

In order to consider all factors above, a specific port assessment should be done in relation to offshore wind requirements. However, one easily assessable factor that also holds great relevance for the fitness of a port to OSW is the cargo depth. The cargo depth refers to the area alongside the quay.

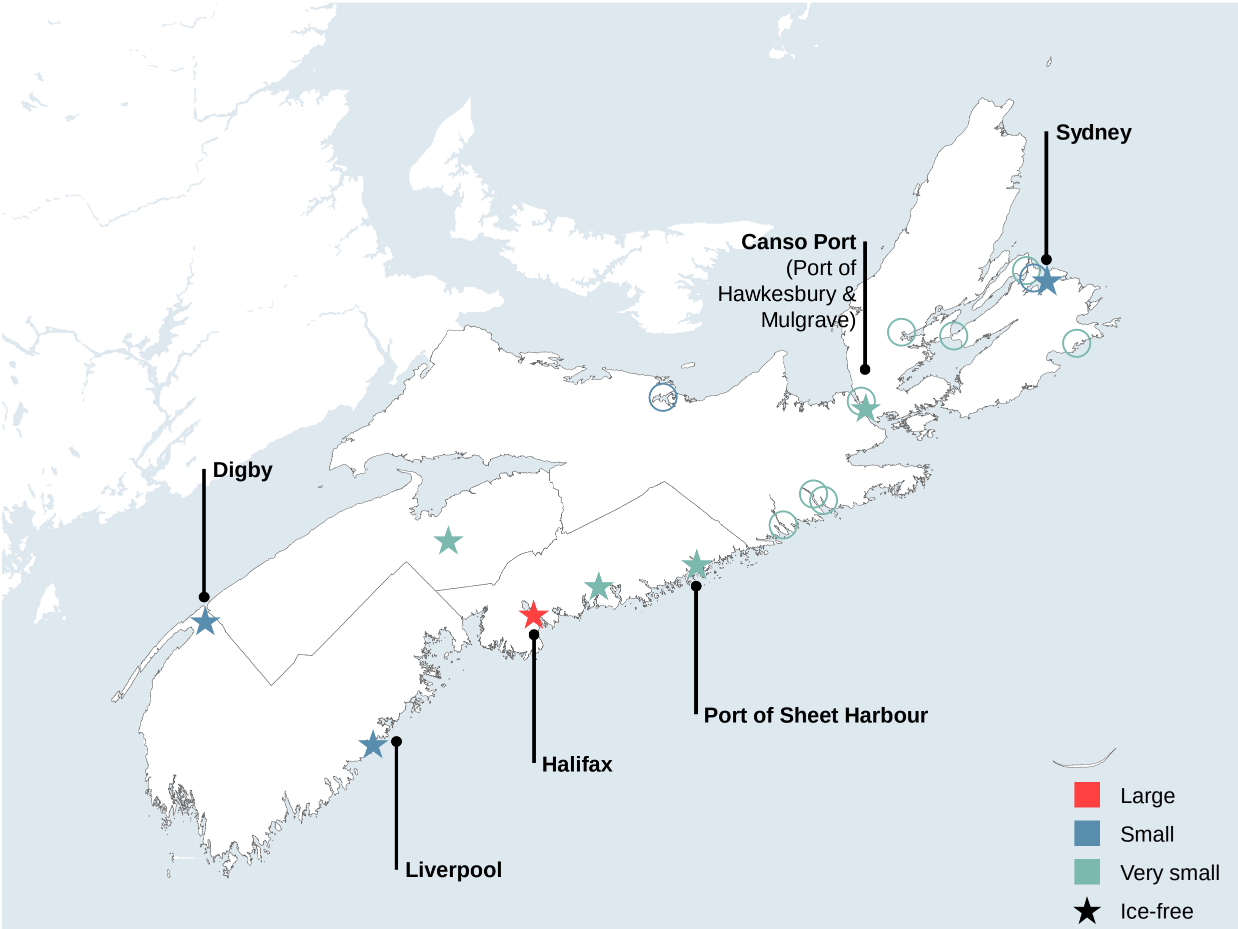
In general, a cargo depth of above eight meters is required, although over 12 meters is preferred to handle all installation vessels in the market. For large ports, this is generally not an issue as it is used to handle large vessels.

Another factor to consider in the case of Nova Scotia is the icing risk in ports. In the north of Nova Scotia, we find ports that have icing during parts of the year. However, two bright spots exist: Port Hawkesbury and Sydney. Although it should be mentioned that the icing status of the latter, Port Sydney, is somewhat uncertain as sources are suggesting conflicting conclusions (WPI, 2020; CPCS, 2018).

Based on the water depth and ice-free requirement, six ports look promising for offshore wind development as seen in **Figure 25**. However, it should again be mentioned that a further port assessment must be made to securely identify suitable ports. Furthermore, the water depth of the Liverpool port is just around 8 meters, meaning there would be some limitations to vessel usage. Lastly, all ports expect Halifax are small or very small, meaning there is a high likelihood that further constraints exist and that port upgrades would be necessary for them to serve as base ports for offshore wind project development.

The port of Halifax however has already played a role in offshore wind project development in the U.S. The now operational 12 MW offshore wind farm in Virginia, consisting of two Siemens Gamesa SWT-6.0-154 turbines, used the port as a construction base to circumvent the Jones' Act.

Figure 25: Port overview with focus on ice-free ports

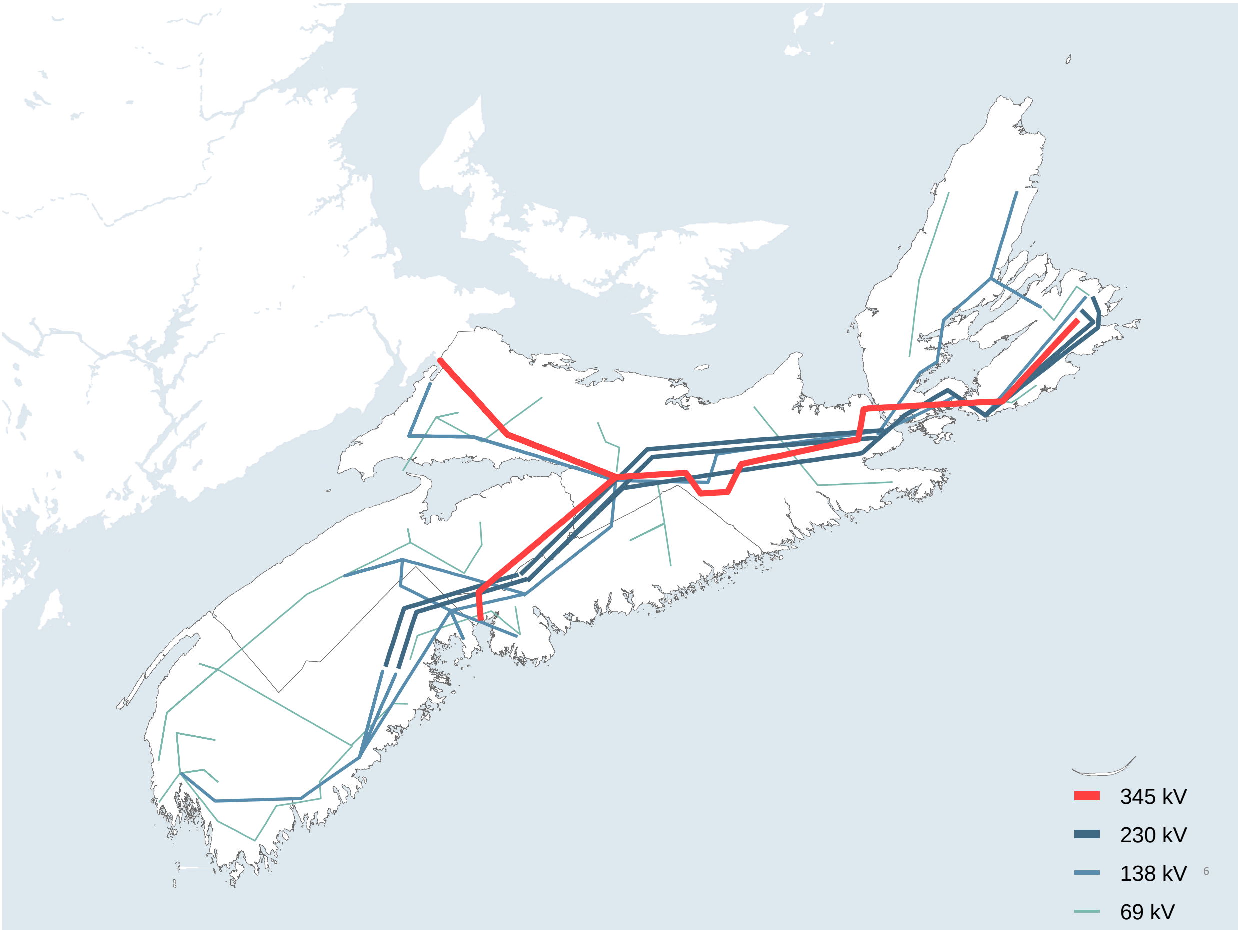


4.3.2 Grid

According to Nova Scotia Power (2020), the transmission and distribution system consists of 31,800 km of power lines. The power lines are categorized into their kV capacity: 69 kV, 138 kV, 230 kV and 345 kV. The province is connected to the neighboring province New Brunswick, enabling import and export of power between jurisdictions.

As can be seen in **Figure 26,** the transmission system can generally handle less capacity in the southern parts of the province. Transmission system infrastructure close to shore is only available close to load centers in Halifax and Cape Breton. This should be considered in the siting process.

Figure 26: Nova Scotia transmission system overview[2]



4.4 Existing siting and permitting process for offshore activities

While offshore wind energy is new to Nova Scotia, offshore energy more broadly is not, and interestingly, the regulatory framework for leasing and permitting of oil and gas effectively works as a one-stop-shop concept. Developers wanting to develop offshore oil and gas projects need only deal with the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) (CNSOPB, 2021).

CNSOPB was established by the federal and provincial governments through the passing of the Accords Acts and functions as the go-to regulatory authority for the entire leasing and permitting process for offshore oil and gas projects.

The leasing and permitting process is divided into four parts, all of which are taken care off by the CNSOPB, as demonstrated in **Figure 27**:

[2] Reprinted from Nova Scotia Power website "How we deliver electricity" (2021)

Figure 27: Steps in the current leasing and permitting process for oil and gas

	Open site nominations and call for bids	Exploration license	Significant discovery license	Production license
Steps for permitting oil and gas	• CNSOPB evaluates lands nominated in an open nomination round and prepares a Strategic Environmental Assessment of the chosen lands • CNSOPB issues a call for bids	• CNSOPB grants the auction winner an exploration license • Any activities the developer wants to carry out require an activity authorization granted by CNSOPB	• CNSOPB grants a significant discovery license if indications of oil and gas are present • Any needed activity authorizations are granted by CNSOPB	• CNSOPB grants the right to extract and produce oil and gas for commercial purposes • Any needed activity authorizations are granted by CNSOPB

First step: Open site nomination and call for bids

Leading up to a call for bids is an open nomination round. Anyone can nominate lands for auction via a Land Nomination form found online. CNSOPB then evaluates nominated lands from a geological and environmental perspective and seeks the counsel of relevant federal and provincial agencies. Marine life, fisheries, indigenous communities, water depth, infrastructure, the likelihood of oil and gas to be found and more is considered.

CNSOPB prepares a Strategic Environmental Assessment (SEA). The SEA is a broad study that identifies potential environmental effects and suitable precautions. CNSOPB then issues a call for bids for a parcel of land on behalf of the federal and provincial governments. The bidding round must last at least 120 days and results in the winner being granted an exploration license. The exploration license allows the developer to begin investigations into the site.

Second step: Exploration license

After having been awarded the exploration license, the developer may begin investigations into the site.

Any activities the developer wants to carry out under the exploration license, such as surveys or drilling, require an Activity Authorization. The application for an Activity Authorization must include an environmental assessment or impact assessment as well as a series of plans that demonstrate the developer's capability of handling various aspects of the activity (Description of Scope and Schedule of Proposed Activities, Safety Plan, Emergency Response Plan and Procedures, Oil Spill Response Plan, Canada-Nova Scotia Benefits Plan, etc.). The developer must also apply for an operating license. CNSOPB appoints a coordinator to facilitate the review from CNSOPB's side and then reviews the application in a collaborative effort across the organisation.

Third step: Significant Discovery License

The exploration licence owner must first apply for a declaration of significant discovery, meaning that an offshore well has been drilled and a flow test has shown that there is enough petroleum to develop the resource for future production.

Any activity the developer wants to carry out under the significant discovery license requires an Activity Authorization. The application procedure is the same as when under an exploration license.

Fourth step: Production license

The developer must first apply for a declaration of commercial discovery, stating that the developer is able to demonstrate that an explored offshore area has enough petroleum resources to justify the investment of capital and effort to produce the resources.

Then a production licence is issued. The license has a term of 25 years, but may be extended, if commercial production is continuing.

5 Ways to stimulate offshore wind in Nova Scotia

5.1 Policy tools stimulating offshore wind in Nova Scotia

This section will present ten specific recommendations for policy tools and instruments relevant for Nova Scotia, whereas the following section will present additional 5 recommendations for enabling of pre-existing conditions for offshore wind development in Nova Scotia.

5.1.1 Agree on a vision and set capacity volume targets

Nova Scotia already has a target to reduce greenhouse gas emissions to 53% below 2005 levels by 2030 and get to net-zero by 2050. On top of this Nova Scotia set a target in 2010 to have 40% renewable energy by 2020 (a deadline recently postponed to 2022). However, there is no carve-out for offshore wind in any of the targets, and as Nova Scotia already has cheap onshore wind as well as hydro-electric power in the mix, it will not be obvious to potential developers that there is an interest in offshore wind development unless expressly stated.

It is Aegir Insights' recommendation to:

1. **Publish a cohesive vision for Nova Scotia's future green energy system**

We recommend publishing a vision for Nova Scotia to achieve the target of net zero emissions by 2050 and add on a target of 100% renewable energy supply by 2050. The vision should include offshore wind contributing from 2030 and onwards, and it could include innovative measures like green hydrogen from offshore wind power figuring into the long-term outlook, if Nova Scotia decides to pursue this strategy.
Premier Ian Rankin already announced that a new Renewable Energy Standard is coming and set a target for green energy: 80% of electricity used in Nova Scotia should come from renewable sources by 2030.

This target of 80 percent can potentially be achieved without offshore wind power; when the Muskrat Falls hydroelectric project in Labrador comes online, bumping the share of renewable energy in Nova Scotia's power consumption significantly up to expectedly around 60%, and if the province manages to contract enough onshore wind farms and maybe solar arrays to get the rest of the way to 80%.

However, the province also needs to phase out coal no later than 2040 – and might aim to do so sooner in light of the current premier Rankin having a target of no coal by 2030 as part of his environmental platform during his Nova Scotia Liberal Party leadership bid (CBC News, 2021).

If these two goals are to be achieved while maintaining energy security, a more diverse energy mix and innovative integrated energy systems are needed, as the need for electricity is only expected to go up as society is electrified.

Offshore wind is an attractive option for diversifying Nova Scotia's energy mix with a local source, thereby creating jobs in-province and heightening energy security by avoiding a too strong dependency on imported energy. Furthermore, offshore wind is one of the best sources for green hydrogen, and energy storage needs to be part of the integrated energy system in future Nova Scotia to ensure stable power supply no matter the weather or the time of day.

It is Aegir Insights' recommendation to:

2. Set offshore wind installation targets: 1 GW by 2030 and 5+ GW by 2050

A carve-out for offshore wind should be incorporated into the new Renewable Energy Standard and preferably made mandatory. Aegir Insights suggests setting a target offshore wind capacity Nova Scotia wants to see operational for provincial use by 2030.

Setting a target of 1 GW offshore wind deployed by 2030 is ambitious but not unrealistic if supported by a roadmap indicating the steps the government will take to ensure the target's realization. The roadmap should indicate that the government will immediately begin overhauling the regulatory framework and screening possible sites.

A second, long-term target of 5+ GW by 2050 is only relevant if Nova Scotia decides to pursue the recommendations termed wildcards in this report. The long-term target should tie in with the overall vision for Nova Scotia's future green energy system as described above and should be of a size that allows for production of green hydrogen at an economically attractive scale, as this plays into the future integrated energy system. Hence it should be at least 5 GW. We recommend looking to similar initiatives in Europe if Nova Scotia should decide to pursue this route, including for instance the Danish plan for building energy islands.

The long-term target will work in tandem with the short-term goal to attract developers, as the short-term target indicates that Nova Scotia is committed and action is coming soon, while the long-term target indicates eventual attractive market size even for larger players. An ambitious long-term target specifically will also encourage investments in local supply chain and knowledge development, meaning jobs in both construction but also for engineers and academics.

5.1.2 Siting, de-risking studies and leasing

Government-led siting and de-risking of sites reduce risks for developers and enable them to submit bids faster, shortening the tender process, as they do not have to wait for results of their own preliminary investigations but can rely on government-supplied data to fabricate a realistic bid.

The siting process also lends itself to important, early stakeholder engagement.

It is therefore Aegir Insights' recommendation to:

3. **Establish development sites through marine spatial planning (Strategic Environmental Assessment) and initiate early de-risking studies (consult with DEA or other responsible authorities in mature markets to estimate costs/benefits of different surveys).**

4. **Set out a timetable for leasing auctions and ensure coordination across government branches to deliver (involve external competences if needed).**

We recommend that Nova Scotia pre-selects the best sites for offshore wind and awards lease and development rights for one site at a time, because this offers opportunities to minimize stakeholder opposition by choosing the least contested areas with adequate wind resources. The ocean around Nova Scotia is important to many stakeholders and many conflicts can be avoided by engaging with the public, particularly fisheries and various environmental protection organizations, early in the siting process.

The authorities should initiate a broad, public hearing round prior to launching the tender. Special focus should be on liaising with the existing steel industry as well as port and fishery communities at the earliest possible stage to delineate areas of interest and single out which areas are not options for offshore wind development due to their importance to other sea users or stakeholders. The government's intention of offering profit-sharing to affected fisheries should be made clear and be considered when delineating possible offshore wind development areas. In parallel with the hearing rounds, the authorities should promote knowledge of offshore wind to the general public and push clear messaging around socio-economic opportunities for Nova Scotia.

Apart from letting the government take the lead on stakeholder engagement, a government-led approach to siting also eases the way into the market for investors who might be reluctant to spend a lot of money upfront on investigating sites before knowing for certain that the market in Nova Scotia will take off. Particularly if Nova Scotia does not choose to go for the wildcard option of a hybrid offshore wind farm including a long-term target of 5+ GW, it will be an easier decision for investors to operate in a Nova Scotia market where sites are investigated and chosen by the government.

Last but not least, the fact that the authorities publishing the tender knows the site or sites well means that the authorities can reasonably place extra demands on the developer regarding the project timeline, making for a more budget-able and dependable build-out process for the government. These demands should be incorporated into the contract signed after the tender and will be touched upon again in a later recommendation.

The results from the government investigations during the siting process should be made public prior to site auctions to ensure lowest LCOE and bid prices.

Exactly which de-risking studies should be made depends on local and local political conditions, and we recommend consulting with experienced authorities from other jurisdictions to evaluate their experiences before making decisions about this.

5.1.3 Draw on oil & gas in creating a one-stop-shop for leasing and permitting

A one-stop-shop for permitting significantly eases the build-out and bankability of projects by providing a degree of certainty regarding the project timeline and effort needed to secure relevant permits. The more fractured permitting processes seen in for instance the U.K. and U.S. make for a more uncertain timeline and costly project development phase as the developer must coordinate with multiple agencies.

It is Aegir Insights' recommendation to:

5. **Create leasing and permitting procedures covering all aspects of offshore wind development under the existing Canada-Nova Scotia Offshore Petroleum Board.**

6. **Encourage early stakeholder engagement by the developer as part of the permitting process.**

As the province already has an inter-governmental framework in place for regulating offshore oil and gas in cooperation with the federal government, Nova Scotia has a good starting point.

The Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) functions as a one-stop-shop for oil and gas operations offshore, permitting on behalf of both the provincial and federal governments. All parts of the process, from determining suitable sites and holding auctions to awarding the relevant licenses to carrying out site investigations and eventually extracting oil or gas for commercial use, are covered by the CNSOPB, meaning that developers only interact with one agency.

The existing legislative framework providing the CNSOPB with the necessary jurisdiction to govern oil and gas development could be extended to cover all kinds of offshore energy production. A future CNSOPB (perhaps renamed the Canada-Nova

Scotia Offshore Energy Board to avoid confusion) covering all kinds of offshore energy would likely save time in the long term by ensuring that possible future developments such as PtX plays could be incorporated without overhauling the entire legislative framework again.

Regarding the permitting process itself, the sequence of steps that make up the leasing and permitting process for oil and gas licensing can be partly reused with modifications for offshore wind as described below in **Figure 28**:

Figure 28: Current leasing and permitting process for oil and gas compared with possible steps in the process for offshore wind

	Open site nominations and call for bids	Exploration license	Significant discovery license	Production license
Steps in the oil and gas process	• Anyone can nominate parcels of Crown lands for auction • Competitive auction is held	• The auction winner is awarded an exploration license with a maximum term of nine years • Exclusive rights to explore for oil and gas and apply for significant discovery and production licenses	• Extends exploration rights indefinitely • Designed to maintain explorer's rights between first discovery and eventual production	• Grants the right to extract and produce oil and gas for commercial purposes
	CNSOPB-led site screening and CfD/FiT auction	**License for site assessment**	**License for construction and operations**	**Production license**
Possible steps in the OSW process	• An expert committee screens potential sites • Results of investigations are made available to developers • Competitive CfD/FiT auction is held	• Auction winner is awarded a site assessment license with a max. term of two years • Exclusive rights to conduct further surveys to be able to propose a design	• Before the site assessment license term runs out, the developer must turn in a COP • If the COP is approved, a license for construction and operations is awarded	• License to produce and sell electricity • When the wind farm has been constructed and becomes operational, the CfD or FiT takes effect

Please note that the above table is meant for inspiration and a point of departure for further discussions. It is a simplified overview and should not be perceived as a guide to the processes.

As can be seen by the table, the main differences between the current process for oil and gas and the possible future process for offshore wind are to be found in the first steps, where we recommend tasking a siting committee with locating sites for development instead of having an open nomination round. We also recommend the committee to lead preliminary investigations and initial stakeholder engagement during the screening process. These actions mean that tighter time constraints may be placed upon the auction winner, as the winner already knows the basics about the site. This translates to a license for site assessment with a term of two years, as opposed to the nine years of an exploration license for oil and gas. This is because the auction winner already knows that there are adequate wind resources and that the site is feasible from environmental and stakeholder viewpoints. All that remains is to conduct more detailed investigations to decide on a design for the wind park and submit a COP.

Stakeholder engagement by the developer should be started early in the process and to ensure this, the COP should be required to contain sections on the local, socio-economic effect of the project including impacts on stakeholder groups and what the project developer has done or will do to minimize negative impacts and maximize positive impacts.

Again, naturally the above descriptions are highly simplified and a large number of intermediary permits, similar to the Activity Authorizations in the oil and gas process, may be needed to continuously ensure that the developer maintains expected standards while carrying out investigations and construction. As long as these are all also granted by the revamped CNSOPB, the process will remain manageable and the project bankable for the developer.

5.1.4 Competitive auctions for renumeration through FiT or CfD

It is important to settle on a design for allocation of lease rights and renumeration early in the process, as it impacts on how investors and developers view the market's attractiveness.

It is Aegir Insights' recommendation to:

7. **Choose either a FiT model or a CfD model, to align with what is considered best practice in the mature markets in Europe.**
8. **Implement competitive auctions for developers to win CfDs or FiTs to ensure lowest electricity prices for ratepayers.**

While it would be natural for Nova Scotia to seek alignment with the U.S. East Coast on many subjects regarding OSW development, we do not recommend following the renumeration models implemented in East Coast states for two main reasons:

1. The East Coast states themselves have differing models, with some using ORECs-based (RECs specifically for offshore wind) models and others going for PPA-based models. The model of each state has arisen from specific conditions in that state as well as the dynamic with the federal side of the process, and as such, true cohesiveness could likely only be achieved between Nova Scotia and a few East Coast states anyway.
2. All renumeration models in the East Coast states are in effect close to the preferred models of FiT or CfD in Europe, models that are non-options on paper to East Coast states because of certain U.S. laws and court rulings. This is not an issue in Nova Scotia.

Both FiT and CfD models provide great financial security to investors, with the FiT completely sheltering the generator from market prices while the CfD can be designed to either completely or partially shelter the generator from the market. If a two-sided hybrid CfD like the one used for Thor offshore wind farm in Denmark is implemented, a small exposure to market prices will remain and incentivize the generator to optimize the energy production to fit better with the market needs, however this small exposure also means potentially higher bid prices in the tender auction.

As the markets in Northern Europe mature, it can be observed that they move towards what is called two-sided hybrid CfDs instead of FiTs, because these CfDs are better at incentivizing the generators to maximize market value of the electricity produced. However, FiTs were widespread among the now mature European markets back when they were emerging and served well in increasing OSW build-out. The same preference for FiT-like models among young markets can be observed in the U.S. East Coast states, where most of the PPAs used so far simply entail an authority or utility paying a fixed price up front to receive the generator's RECs and electricity for 15-20 years – in effect more like a FiT than a CfD. Nova Scotia also already has experience with using FiTs to support for instance tidal power and small renewable energy community projects via the now defunct COMFIT program.

Whether a FiT or CfD is chosen as renumeration model, the contract should be awarded through a competitive auction where the lowest price offered wins (so long as the bid adheres to the tender specifications). Concession payments should be avoided, as they will raise the price of electricity.

The contract regulating the renumeration should be designed to ensure a timely delivery of the project. There should be no option for opting out, to avoid developers submitting unrealistically low bids and then opting out.

Requirements regarding delivery schedule should be incorporated. These can for instance include a requirement to demonstrate financial commitment no later than one year after winning the auction. The auction winner can demonstrate financial commitment to the project by showing evidence of investments so far. Another often used requirement is for the renumeration model (whether it is a CfD or a FiT regulated through a PPA) to take effect no later than a certain year. For instance, the renumeration model can be scheduled to begin no later than 2031. If the project is ready for operation before, then the renumeration can begin earlier, but if the project is not ready, the developer loses whatever renumeration was set to be given from 2031 until the project comes online.

Last, but not least, a longstop date can function as an overall deadline for the commissioning of the project. If the project is not at a satisfactory stage by this date, the whole contract is terminated so that the area can be auctioned anew.

5.1.5 Generator-build grid connection model

Timely and long-term state-led grid connection build-out planning is key from a developer/investor perspective – if grid upgrade costs are uncertain or not state-led it can be a showstopper for serious developers. Clear targets and a timeline will help plan for accurate infrastructure upgrade needs.

It is Aegir Insights' recommendation to:

9. **Mandate transmission reinforcements**

If any grid reinforcements are needed to cater for the selected offshore wind projects, they should be included and prioritized in the scenario planning.

Transmission systems make up a substantial portion of the overall cost of an OSW project, typically 25-30% of the total investment. Thus, it is important that the preferred offshore transmission model, including planning, construction and ownership responsibilities, is determined and communicated to the industry.

It is Aegir Insights' recommendation to:

10. **Implement a radial-approach to transmission design and a generator-build model**

A network-based offshore transmission system is not seen to be a relevant path for Nova Scotia due to lack of constraints and a limited build-out. The generators will be able to connect their projects to the grid in a fast and efficient manner and will likely prefer to handle it themselves.

5.2 Promotion of pre-existing, enabling conditions

Nova Scotia possesses strong port infrastructure and industrial skills relevant to offshore wind development, such as experience with shipbuilding for the marine defense industry and experience from the oil and gas and tidal energy sectors. Academic institutions including four research centers mean that Nova Scotia has the knowledge base and options to expand relevant education as well.

Further, Nova Scotia's coastal location and maritime history provides opportunities for local vessel providers.

Nova Scotia should support and promote enabling conditions for offshore wind that already exists within the province. Aegir Insights sees primarily the existing highly skilled workforce and the presence of educational institutions, the existing supply chain within ocean science related areas, and the port infrastructure that could be used by both domestic and U.S. projects to be areas where action should be taken.

Inspired by the recent Green Jobs Taskforce initiative in the U.K., the government of Nova Scotia should create a special body supporting the development of long-term green jobs.

It is Aegir Insights' recommendation to:

11. Establish a dedicated task force to support economic development

Focus areas of the initiative promoting green jobs in Nova Scotia could amongst others be to convert an already skilled workforce into the offshore wind specific supply chain. A starting point could be to convert the existing maritime sector into offering surveys and investigations during siting. These surveys include wind resource measurements, geophysical and geotechnical analyses of the seabed as well as metocean data collection and environmental assessments. By enabling investment in benefit schemes, existing industries can develop expertise specifically for offshore wind.

12. Enable investment in local supply chain businesses

In parallel, needed skills for the local supply chain in focus should be mapped to target relevant apprenticeships and educational programs.

13. Undertake skills and training assessment

To develop new talent within offshore wind, a program across educational institutions focusing on ocean sciences should be implemented. The program should target white-collar workers and involve offshore wind specific topics including emerging technologies, such as floating wind, as well as energy system integration technologies, such as long-duration storage.

14. Offer education that generates green jobs in Nova Scotia

Ports in Nova Scotia will be essential for a provincial build-out and could be a major opportunity to support the offshore wind development in the U.S., that will have a large build-out in the coming year. The initiate should target blue-collar workers.

15. Prepare and invest in infrastructure (ports, transmission)

Based on an initial screening, many of the ports in Nova Scotia meet the basic requirements to support offshore wind. However, we recommend that a port assessment of the suitable ports is done as soon as possible, and that costs of necessary upgrades to existing ports are assessed as part of this. This will be important information to know when evaluating potential offshore wind farm locations in a siting process. An important consideration to make when evaluating port upgrades is the requirements for serving the booming U.S. offshore wind industry (depth requirements for installation vessels and assembly facilities).

5.3 Wild cards

On account of the rapidly evolving offshore wind market and considering the time horizon of a potential build out in Nova Scotia, it is strategically relevant to consider a number of emerging and highly ambitious opportunities beyond conventional offshore wind – called ‘wild cards’ in this report.

Offshore wind has proven itself a key technology to the energy transition on account of its demonstrated low deployment risk, ability to be deployed in an industrialized manner at large scale and having relatively high-capacity factors in comparison to competing renewable technologies. Because of these features, many leading energy investors are looking at offshore wind as a ‘centerpiece’ to build much larger energy transition developments around. There is also evidence that major offshore wind developers and OEMs are re-organizing their businesses around being able to supply multiple energy transition technologies together with offshore wind, a concept being termed ‘hybrid’ solutions.

Looking at the time horizon of possible deployment of offshore wind in Nova Scotia, conventional fixed bottom projects would undoubtedly provide a degree of local economic opportunity and needed low carbon electricity. But in the context of the global offshore wind sector, Nova Scotia would be a small market. If Nova Scotia deploys more innovative solutions however, it could gain an early mover advantage, which could provide greater opportunity for development of intellectual property, supply chain, research, and other related benefits.

Aegir Insights briefly presents two example concepts which would go beyond conventional offshore wind and place Nova Scotia at the leading edge of emerging energy transition technology; 1) Establish a “’hybrid hub’ powered by offshore wind, and 2) Establish demonstration-scale floating wind.

5.3.1 Establish a ‘hybrid hub’ powered by offshore wind

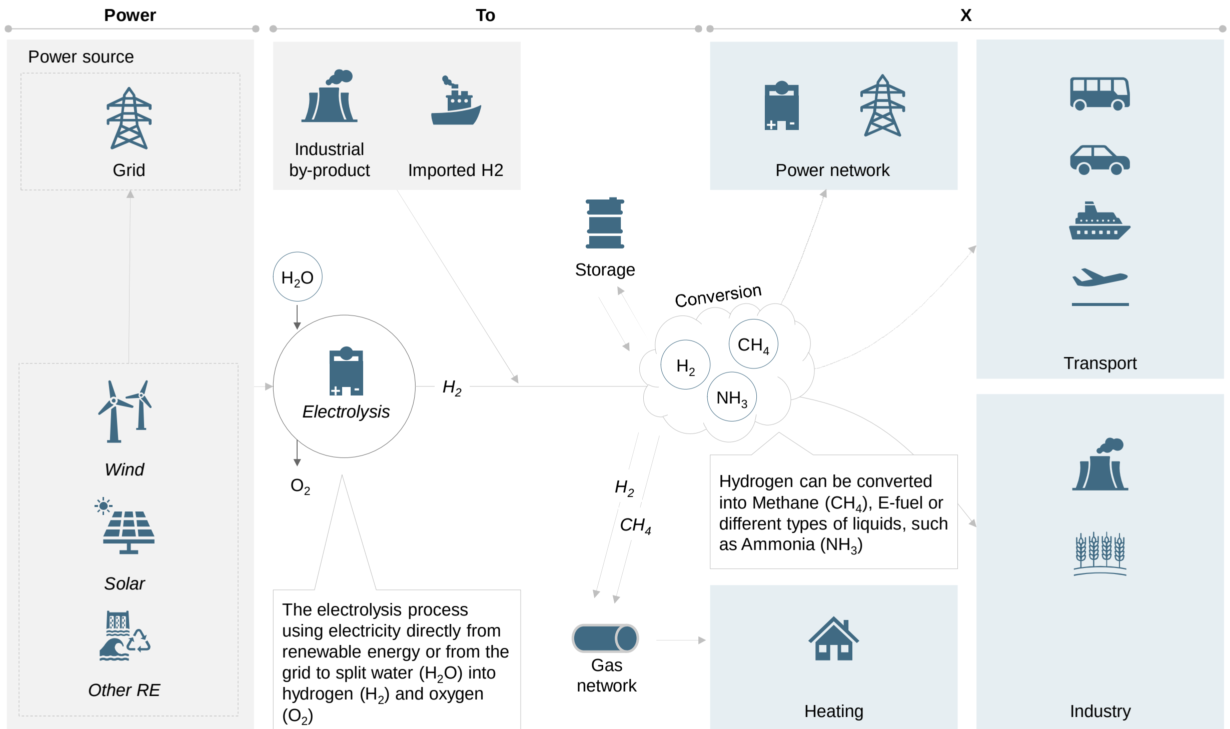
Developers, investors, and policy makers around the world are recognizing that offshore wind is moving towards low cost and large scale, hence markets are moving towards encouraging solutions which are hybrid – meaning the offshore wind park is combined with various forms of system integration technology. Hybrid energy projects leverage the complementary generation profiles of a combination of technologies to achieve a more ‘baseload like’ profile and numerous grid benefits. A common technology mix considered for hybrid offshore projects are offshore wind, solar, energy storage (short and/or long duration) and PtX (hydrogen or other). In addition, customers may achieve overall better value for investment on account of sharing land, grid infrastructure and operations and maintenance services for the different assets.

Looking to the Dutch offshore wind market, one can find the most ambitious example of a hybrid offshore wind project to date in the Shell and Eneco CrossWind consortium’s Hollandse Kust (noord) project. CrossWind has committed to construct the 759-megawatt offshore wind farm project without subsidy, to be operational by 2023 including linkage to demonstration scale floating solar, storage and hydrogen generation. The Dutch government’s tender terms for the Hollandse Kust (noord) offshore wind park encouraged participants to incorporate hybrid ‘system integration’ solutions (Windeurope, 2020).

In Denmark “Vindø Island” will be the world’s first energy island, producing energy from offshore wind turbines and utilizing energy storage and Power-to-X.

Nova Scotia’s waters have exceptional wind conditions, providing competitive siting for hybrid solutions which benefit from low-cost offshore wind. In the timeframe of a potential offshore wind buildout in Nova Scotia, the province could secure a position as a first mover on large scale hybrid offshore wind parks, providing advantages in terms of intellectual property, supply chain and research and attracting leading energy players.

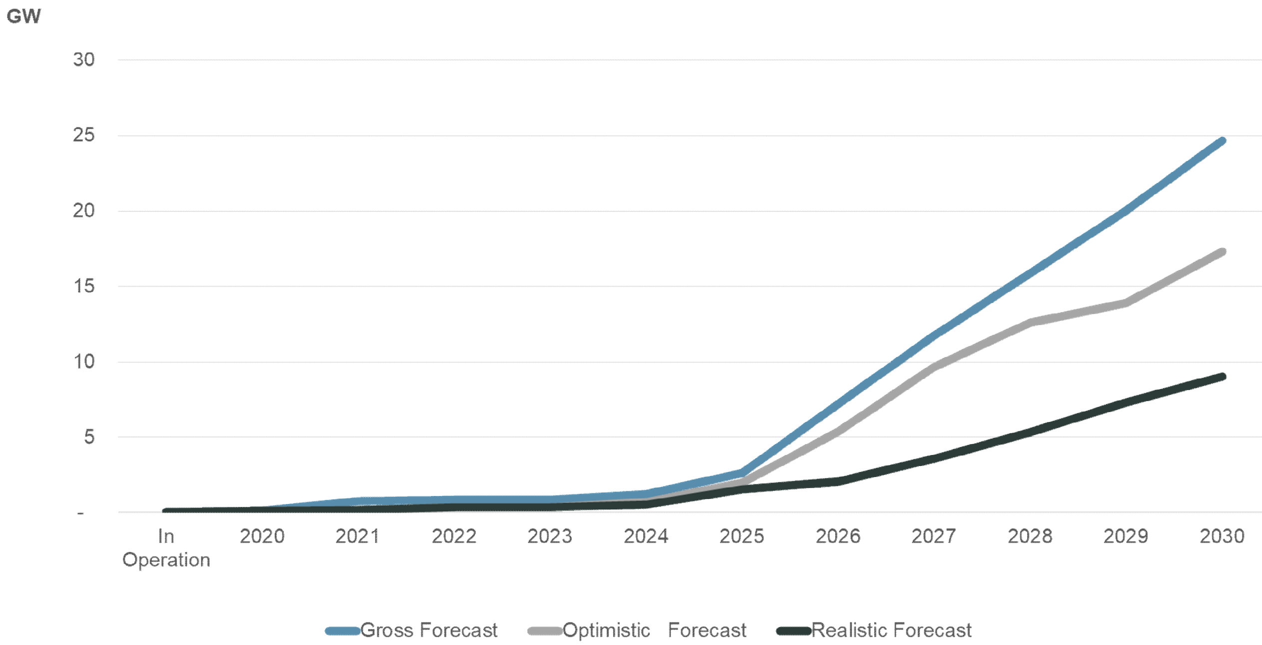
Figure 29: Power-to-X system overview



5.3.2 Establish a demo-scale floating offshore wind

Floating wind technology is at the precipice of commercialization, with the upscaling and demonstration of several competing designs underway. The commercial market for floating offshore wind is expected to take shape from 2025 onward, initiating in locations such as Scotland, Norway, South Korea and Japan. Projections estimate 6 to 12 GW deployed globally by 2030, up from less than 0.1 GW today (Aegir Insights, 2020).

Figure 30: Forecast 2020-2030 of floating wind capacity based on three scenarios



The timing of floating offshore wind commercialization could provide an opportunity to adapt Nova Scotia's experience with marine energy demonstration to play a key role in the emerging floating offshore wind market. Several technology challenges remain for floating wind to reach large commercial deployment, including shallow mooring concepts, dynamic array cables as well as operations and maintenance concepts.

In establishing demonstration-scale floating wind, there would be substantial transferrable experience from the FORCE tidal demonstration facilities. Opportunities to export know-how to other regions such as the U.S. East Coast and the Caribbean would arise as these regions turn to floating wind solutions.

A technology test center could be carried out either as a standalone project, or as a test site in connection with a commercial project, sharing infrastructure for cost efficiency.

6 Roadmap: Plan and timeline

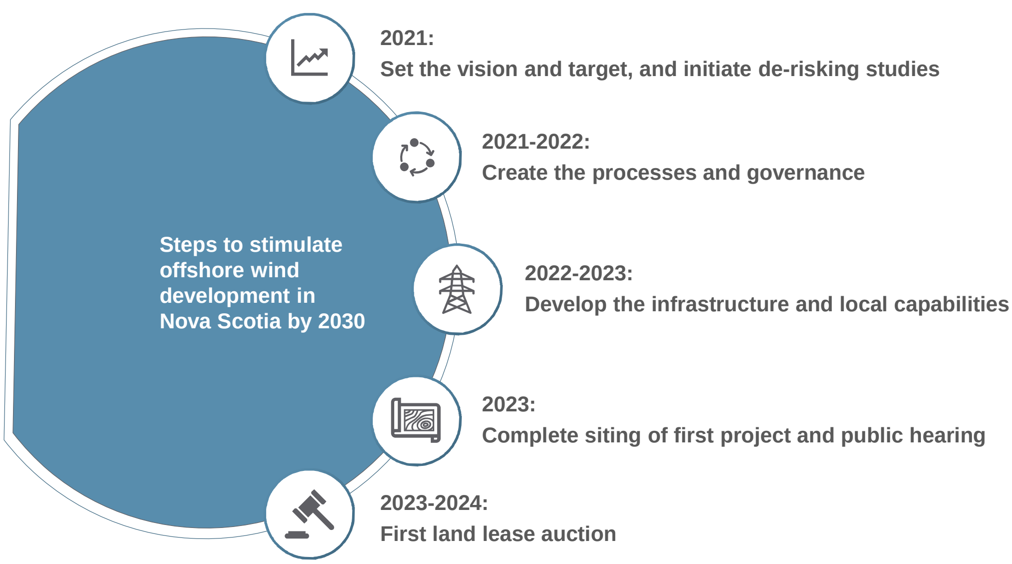
This section will summarize the recommendations and wild cards for stimulating OSW development in Nova Scotia. The identified policy tools relevant for Nova Scotia to consider are based on ten specific recommendations as summarized in **Figure 31**.

Figure 31: Recommendation on policy tools for OSW development in Nova Scotia

Overall recommendation	Actionable sub-recommendations
I. Agree on a vision and set capacity volume targets	1. Publish a cohesive vision for Nova Scotia's future green energy system 2. Set offshore wind installation targets: 1 GW by 2030 and 5+ GW by 2050
II. Siting, de-risking studies and leasing	3. Establish development sites through marine spatial planning (Strategic Environmental Assessment) and initiate early de-risking studies (consult with DEA or other responsible authorities in mature markets to estimate costs/benefits of different surveys) 4. Set out a timetable for leasing auctions and ensure coordination across government branches to deliver (involve external competences if needed)
III. Draw on oil & gas in creating a one-stop-shop for leasing and permitting	5. Create leasing and permitting procedures covering all aspects of OSW development under the existing framework of the Canada-Nova Scotia Offshore Petroleum Board 6. Encourage early stakeholder engagement by the developer as part of the permitting process
IV. Competitive auctions for renumeration through FiT or CfD	7. Choose either a FiT model or a two-sided hybrid CfD model, to align with what is considered best practice in the mature markets in Europe 8. Implement competitive auctions for developers to win CfDs or FiTs to ensure lowest electricity prices for ratepayers
V. Generator-build grid connection model	9. Mandate transmission reinforcements 10. Implement a radial-approach and generator-build model

The above recommendations can be linked to five steps illustrating the route to realizing the first offshore wind deployment in Nova Scotia by 2030, assuming a development lead-time from lease award to offshore deployment of about five years.

Figure 32: Steps for stimulating offshore wind development in Nova Scotia



Furthermore, five specific recommendation for promotion of pre-existing enabling conditions for stimulating offshore wind in Nova Scotia are illustrated in **Figure 33**.

Figure 33: Recommendation on promotion of enabling conditions for offshore wind

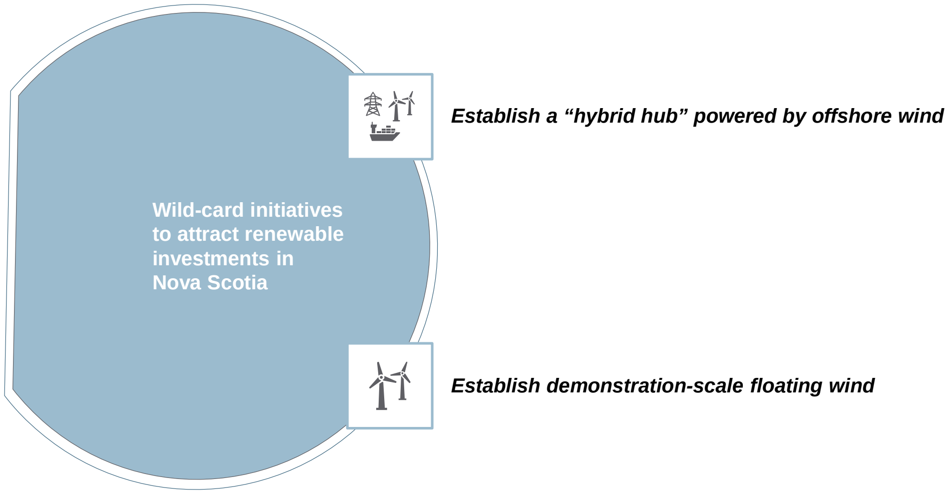
Overall recommendation	Actionable sub-recommendations
	11. Establish a dedicated task force to support economic development
	12. Enable investment in local supply chain businesses
Support and promote enabling conditions for offshore wind that already exists within the province	**13.** Undertake skills and training assessment
	14. Offer education that generates green jobs in Nova Scotia
	15. Prepare and invest in infrastructure (ports, transmission)

The total 15 recommendations are to be considered in future consultations between relevant government branches, the offshore wind industry and other stakeholders.

It is important to note that a one-off offshore wind project in Nova Scotia would be seen as a limited opportunity by offshore wind developers and investors, as Nova Scotia will be competing with other offshore wind markets with longer project pipelines announced. To increase attention from the global offshore wind market participants and thereby attract more competitive bids, Nova Scotia should consider the wild cards suggested in this report. An ambition to deploy the first “hybrid offshore wind project” by 2030 followed by a larger scale “hybrid hub powered by offshore wind” by 2050 would resonate well with industry trends.

The presented wild cards speak to providing Nova Scotia with a competitive edge in the global offshore wind industry. These are illustrated in **Figure 34**.

Figure 34: Wild-cards ideas for offshore wind development in Nova Scotia



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This report has been edited to change any reference of Offshore Energy Research Association (OERA) to Net Zero Atlantic (NZA) as OERA transitioned to NZA in 2022 after this report was completed.