9b Processes for planning & building offshore wind & transmission

Modules for Maturing HVDC Electric Transmission Knowledge

Primary Author	James McCalley, Iowa State University
Email Address:	jdm@iastate.edu
Co-author:	
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Prerequisite Competencies:	1. Motivation of HVDC for offshore wind as found in Module 1c.
Module Objectives:	1. Identify/describe the sequence of work necessary to plan and develop offshore HVDC transmission along US coasts; 2. Compare and contrast the US processes with those of various countries throughout the world.

Abstract

HVDC transmission is attractive for offshore wind applications because it can provide submarine power transfer at relatively high levels of capacity. However, the processes necessary to plan and build offshore wind together with the necessary transmission are new, with complexities stemming from deployment in both marine and land-based regions involving multiple organizations, including governmental agencies charged with oversight of coastal waters, transmission planning coordinators and utility companies, and various agencies representing the interest of state and local governments.

The objective of this module is to identify the sequence of work necessary to plan and develop offshore wind and the necessary transmission. The module focuses on the US situation but also identifies salient differences in the situation of other regions in the world. Section 9b-1 introduces the topic and provides a high-level outline of the overall process. Section 9b-2 provides essential background in terms of ocean jurisdictions and the existing state of offshore wind in the US. Sections 9b-3 through 9b-7 summarize the main steps necessary for offshore wind and transmission development in the US, including the permitting roles of specific agencies in each state. Section 9b-8 describes cost allocation procedures and the related role of the Federal Energy Regulatory Commission (FERC). Section 9b-9 compares US processes with those of other countries throughout the world, including various European countries, particularly those having North Sea coastline. The main learning points of the module are summarized in Section 9b-10.

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Acronyms

AC	Alternating current
BOEM	Bureau of Ocean Energy Management
COP	Construction and operations plan
CZMA	Coastal Zone Management Act
DC	Direct current
DOJ	Department of Justice
EPACT	Energy Policy Act of 2005
FERC	Federal Regulatory Energy Commission
GAP	General activities plan
GIQ	Generation Interconnection Queue
HVDC	High voltage direct current
ISO-NE	Independent System Operator of New England
MW	Megawatt
MMM	Multispectral multibeam mapping
NHPA	National Historic Preservation Act
NYISO	New York Independent System Operator
PJM	Pennsylvania-Jersey-Maryland
POI	Point of interconnection
RTO	Regional Transmission Organization
ROW	Right of way
RUE	Right-of-use
SACA	Simultaneous ascending clock auction
SAP	Site assessment plan
SPI	Sediment profile imagery
UK	United Kingdom
UNCLOS	United Nations Convention on the Law of the Sea
VSC	Voltage sourced converter

9b-1 Introduction

Offshore wind development requires a process of planning, permitting, and engineering that involves not only the standard steps required for development of conventional onshore resources, but also those related to the unique features of deploying generation and transmission technologies in coastal waters. This module identifies and describes those steps. The objective of this module is to identify the work sequence necessary to plan and develop offshore transmission, and to describe the major steps, including those that would relate to the deployment of high-voltage direct current (HVDC) transmission. Because the need for offshore transmission is motivated by the development of offshore wind, the work sequence described also includes that required for the offshore wind generation facilities. The module focuses on the US situation but also identifies salient differences in the situation for other regions in the world.

Section 9b-2 addresses international and US coastal jurisdictions, to provide context for identifying who has authority to establish procedures for offshore wind development. Sections 9b-3 through 9b-7 describe the four major steps of offshore wind development, as depicted by the four columns in Figure 9b - 1. Figure 9b - 2 provides the timeline for these steps. which heavily involves the Bureau of Ocean Energy Management (BOEM). Section 9b-8 describes the transmission cost allocation policies of the US Federal Energy Regulatory Commission (FERC), Section 9b-9 summarizes procedures in other countries, and Section 9b-10 summarizes main learning points for this module.

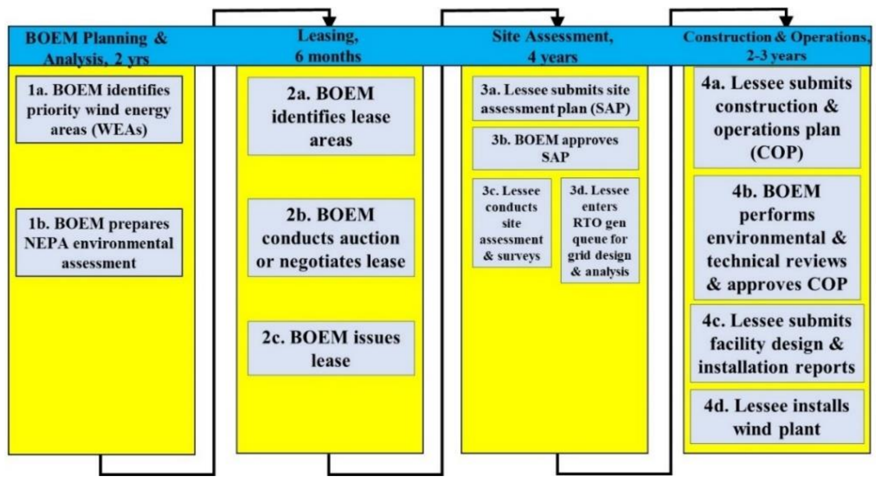

Figure 9b - 1: Main steps of offshore wind development

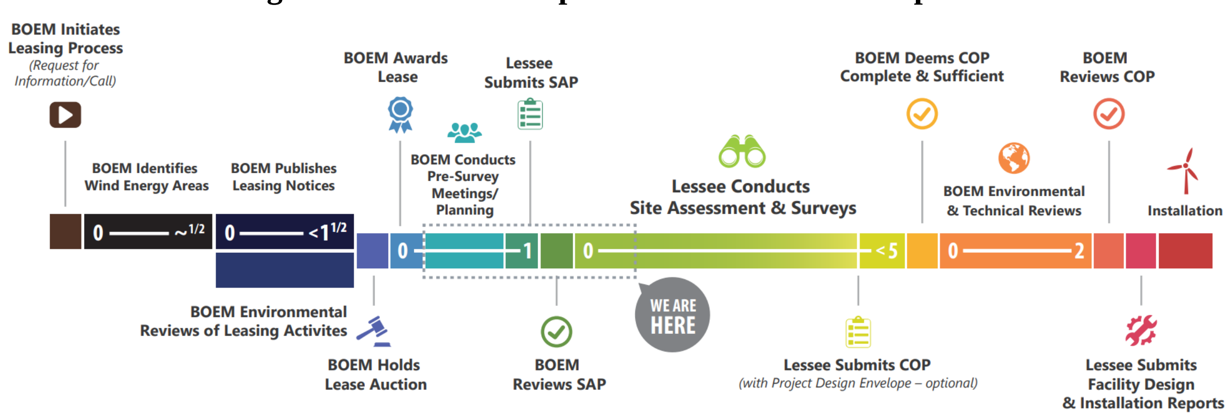

Figure 9b - 2: BOEM's timeline of offshore wind development

9b-2 Background

Ocean jurisdiction refers to the authority or power of a government (federal, state, or local) to enact and enforce laws, regulations, and decisions regarding its use and management. Understanding ocean jurisdiction is central to the characterization of offshore wind development processes. In this section, we summarize ocean jurisdictions, with interest internationally, but focusing on the US. We also identify the state of offshore wind in the US as if 2025.

9a-2.1 Ocean jurisdictions

Before 1945, the definition of “coastal waters” was in accordance with the eighteenth-century Freedom of the Seas doctrine, which limited any nation's ocean rights to a 3-mile region surrounding its coastline, declaring the remainder to be free to all nations. However, in 1945, President Harry Truman, via Presidential Proclamation No. 2667 [1], extended US jurisdiction to include all resources within the continental shelf. Then, in 1982, the United Nations organized the “Convention on the Law of the Sea,” [2] which shifted a nation's territorial ownership based on the "continental shelf" to a 200-nautical-mile (230 miles) limit it named the exclusive economic zone (EEZ). It was signed by 117 States in 1982, affirmed in the US by President Ronald Reagan via Presidential Proclamation in 1983 [3], and entered into force internationally in 1994.

The 200-nautical-mile region is measured relative to the *normal baseline* (NB, also called the *national baseline*); the NB was defined in the 1958 “Geneva Convention on the Territorial Sea and the Contiguous Zone” [4] and entered into force internationally on September 10, 1964. This baseline, illustrated in Figure 9b - 3 [5, 6], is the region’s low-water line along the coast as marked on large-scale charts officially recognized by the coastal nation. Because low water is not an official tidal datum, the U.S. applies the term to reference the lowest charted datum, which is the mean lower low water (MLLW) [7]. The EEZ is measured from the NB. Since coastlines change over time, the NB changes as well. BOEM uses the Boundary Delineation System (BDS) to identify the NB and as a result, also BOEM’s mission areas [8]. The BDS is “a collection of procedures, data, and geographic information system software used exclusively by the Geospatial Services Division (GSD) staff [within BOEM]” to perform offshore boundary computations and generate diagrams to depict information related to the outer continental shelf (OCS) [9].

The authority over offshore wind energy development shifted from the Army Corps of Engineers under the Department of Defense, to the Department of Interior in 2005 with the enactment of the Energy Policy Act (EPAct), which amended the Outer Continental Shelf Lands Act (OCSLA). The authority to regulate activities related to production, transportation, or transmission of energy from sources other than oil and gas [10] in the EEZ, including oversight of EEZ renewable energy development, resides with the Department of the Interior. This authority was delegated to BOEM (an agency of the Department of Interior), as provided in the 1953 Outer Continental Shelf Lands Act [11, 12], specifically from amendments to subsection 8(p) as set forth in section 388(a) of the Energy Policy Act of 2005 (EPAct) (Pub. L. 109-58) [13], and updated in the 2024 Renewable Energy Modernization Rule [14, 15].

Figure 9b - 3 also illustrates state waters, territorial sea, and the contiguous zone. In the US, *state waters* resulted from the 1953 Submerged Lands Act; it refers to a region extending 3 nautical miles seaward from the baseline, giving states jurisdiction “to the natural resources within such lands and waters, to provide for the use and control of said lands and resources” [16]. The only exceptions to this are Texas, the Gulf Coast of Florida, Louisiana, and Puerto Rico, where state waters extend 9 nautical miles from the baseline. Coastal states control siting for offshore wind projects in state waters, i.e., each coastal state has authority within its state waters to regulate and permit offshore wind and/or its connections to land. Procedures vary significantly among the states. As of 2025, there is only one wind farm in state waters - the 30 MW Block Island Wind Farm off the coast of Rhode Island (as of 2025, there are only two other US offshore wind farms of any kind: the 12 MW Coastal Virginia Offshore Wind Pilot Project, and the 132 MW South Fork Wind Farm, and both are in federal waters).

In addition to state waters and the EEZ, Figure 9b - 3 also illustrates the *territorial sea* as the region 0-12 nautical miles from the baseline, and the *contiguous zone* as the region 12-24 nautical miles from the baseline. The territorial sea designates a region for which "the coastal State[1] exercises full sovereignty over the air space above the sea and over the seabed and subsoil" [17]. In its contiguous zone, a coastal State[1] "may exercise the control necessary to prevent the infringement of its customs, fiscal, immigration, or sanitary laws and regulations within its territory or territorial sea, and punish infringement of those laws and regulations committed within its territory or territorial sea" [5].

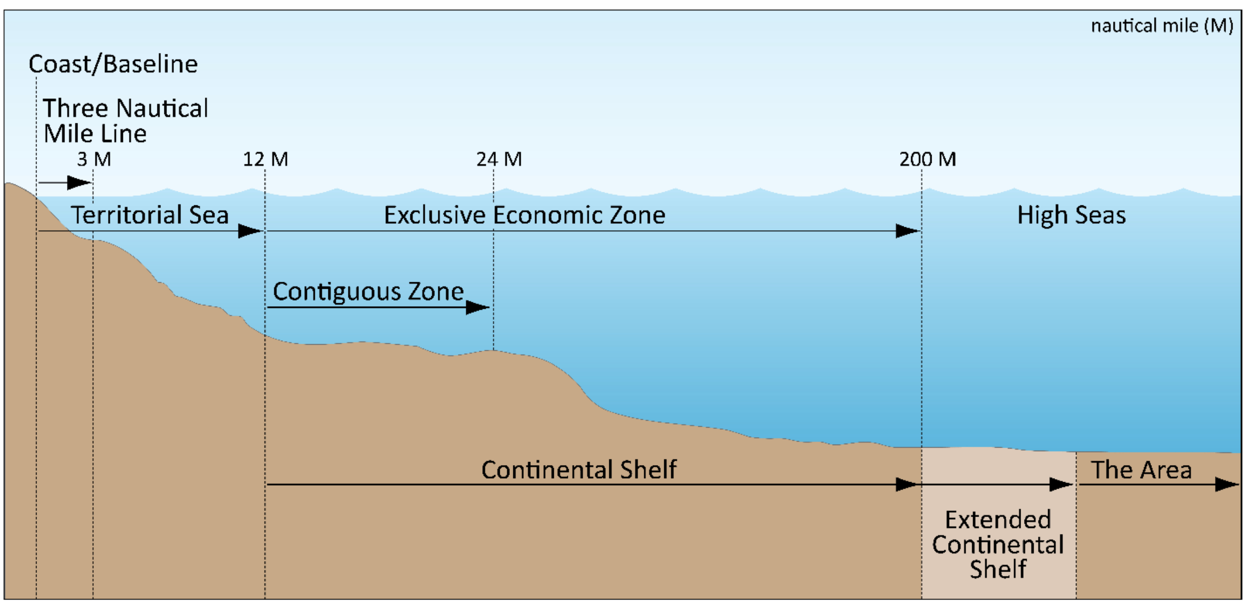

Figure 9b - 3: Jurisdictional offshore regions [5]

9a-2.2 2025 US state of offshore wind

As of July 2024, at least 27 leases of offshore wind projects in federal waters had been issued [18], representing approximately 27 GW of potential installed capacity. But on January 20, 2025, President Trump issued a presidential memorandum [19] to withdraw from disposition for wind energy leasing all areas in federal waters (explicitly "…within the Offshore Continental Shelf (OCS) as defined in section 2 of the Outer Continental Shelf Lands Act, 43 U.S.C. 1331"). With respect to existing leases, the memorandum requires that the Secretary of the Interior, "in consultation with the Attorney General as needed, shall conduct a comprehensive review of the

[1] Here, the phrase "coastal State" refers to the nation, i.e., in the US case, it refers to the federal government.

ecological, economic, and environmental necessity of terminating or amending any existing wind energy leases, identifying any legal bases for such removal." In March 2025, BOEM's staff of about 700 people was significantly reduced [20], with 39 active leases for offshore wind [21].

Because there is only one operational wind farm in state waters and only one other windfarm proposed for state waters (the 11 MW Aqua Ventus I plant in Maine, a demonstration project), President Trump's memorandum effectively pauses all active US wind farm development. This raises the question: to what extent will work continue for US offshore wind development? It is probable that US offshore wind development will come to a halt, at least for the duration of the Trump administration (see 11 min video interview of Trump Administration Energy Secretary Wright and Interior Secretary Burgum, particularly the section of (min:sec) 5:20-7:20, where Secretary Burgum indicates "we've swung too far in the way of the intermittent, unreliable" link). Indeed, ongoing construction on the fully-permitted Equinor-owned 810 MW Empire Wind project, off the coast of Long Island, New York, was halted by the Trump Administration on Wednesday, April 16, 2025 [22]. Nonetheless, there are three ways that some US offshore wind development may still occur during this time: (i) one or more of the existing active leases could be continued; (ii) offshore wind could be developed in state waters; and/or (iii) the order contained in the 2025 presidential memorandum [19] could be lifted.

The remainder of this module is written to communicate those processes and procedures for US offshore wind development that were in place before the Trump memorandum and related staffing cuts at BOEM. The underlying rationale for doing so is that, should offshore wind experience a resurgence, it is likely that those processes and procedures will either be reinstated, or they will serve to guide the reestablishment of new processes and procedures.

INDUSTRY INSIGHT

As of January, 2025, there had been 11 permits issued for offshore wind farms totaling over 19 GWs [23, 24], three of which are under construction and include the 806 MW Vineyard Wind 1 off the coast of Martha's Vineyard, Massachusetts, the 704 MW Revolution Wind to supply Connecticut and Rhode Island, and the 2600 MW Coastal Virginia Offshore Wind off the coast of Virginia Beach. Three US projects have been completed, the largest and most recent of which is the 132 MW South Fork Wind off Long Island [25]. These projects are identified by developer and status in Figure 9b - 4 [23]. Explanatory notes for this figure include (i) operational capacity does not include South Fork because it was not operational at the time the figure was created (1/2025); (ii) since some projects have multiple developers, the GWs in the figure are allocated accordingly; (iii) all projects operational or under construction have a secured electricity buyer.

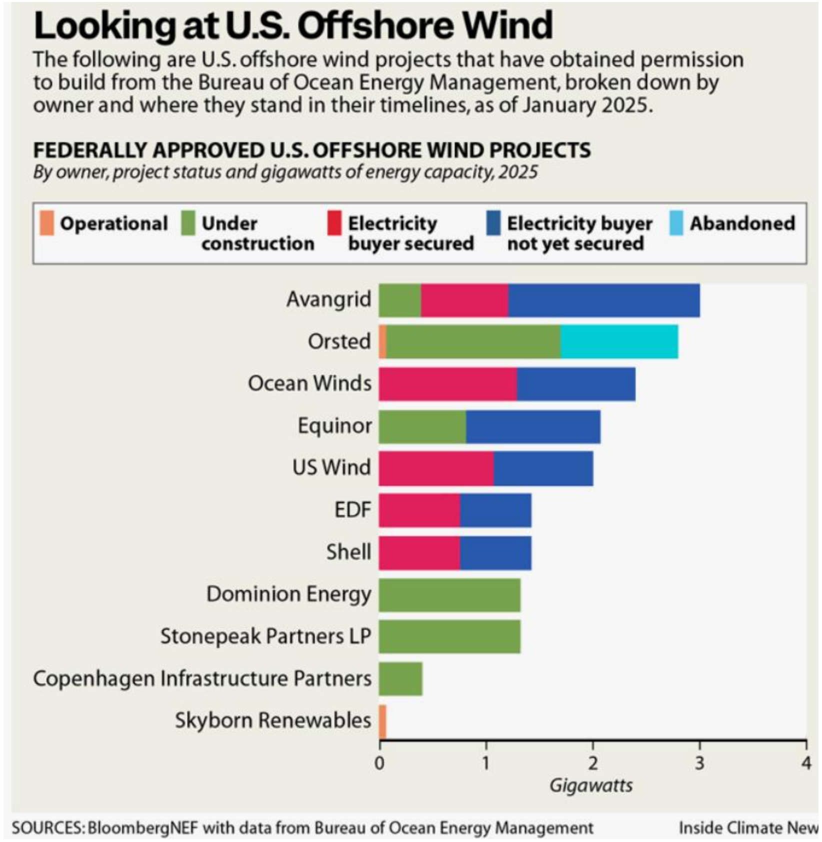

Figure 9b - 4: US offshore wind by developer and status [23]

9b-3 BOEM planning & analysis

BOEM has three mechanisms by which it may grant use of an offshore region: lease sale, right-of-way (ROW) grants, and right-of-use (RUE) grants. BOEM uses a *lease sale* for the purpose of building and operating offshore wind farms; the lease grants exclusive rights to the lessee for a defined period, allowing them to develop and utilize the area for wind energy projects. On the other hand, a ROW grant is used to authorize construction and use of cables to transport the electric energy from the windfarm to shore. A RUE grant is like a ROW grant but focuses on construction of platforms, seafloor production equipment, and artificial islands.

The planning and analysis phase seeks to identify suitable areas for wind energy leasing consideration through collaborative, consultative, and analytical processes that engage stakeholders, tribes, and State and Federal government agencies. In this phase, BOEM conducts environmental compliance reviews and consultations with Tribes, states, and natural resource agencies. The standard sequence of work includes three main steps, as described in Subsections 9a-3.1, 9a-3.2, and 9a-3.3 and as illustrated in Figure 9b - 5 [26].

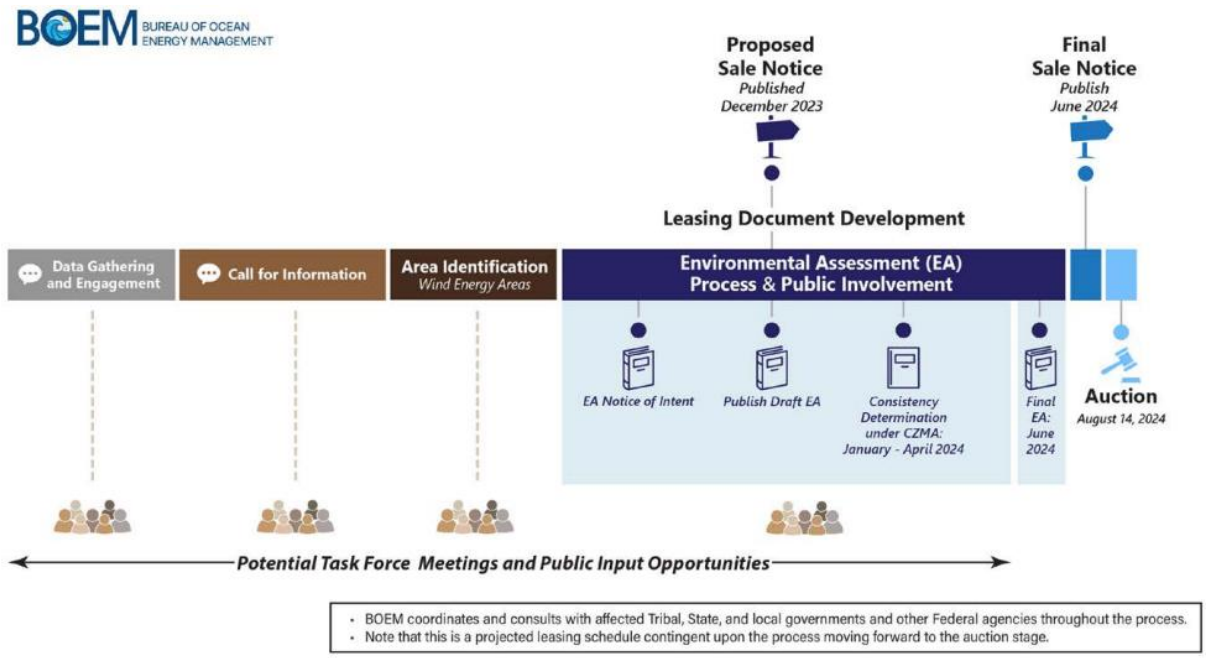

Figure 9b - 5: BOEM planning and analysis [26]

9a-3.1 Establish task force

The planning and analysis phase often begins with states or territories requesting that BOEM establish an Intergovernmental Renewable Energy Task Force for their state, territory, or region [27]. Task forces may include representation from federal, state, local, and Tribal governments. The primary purpose of these task forces is to serve as an information hub for potential offshore renewable energy activities. As of 2025, BOEM had established task forces for the Gulf of Mexico [28], Guam [29], New Jersey [30], California [31], the Central Atlantic [32], Hawaii [33], Oregon [34], the Gulf of Maine [35], New York [36], Virginia [37], and Carolina Long Bay [38]. Some of these task forces address the interests of multiple states, e.g., the Gulf of Maine Intergovernmental Renewable Energy Task Force includes Maine, New Hampshire, and Massachusetts.

9a-3.2 Issue request for interest (RFI)

BOEM may publish an RFI in the Federal Register (FR), with a specified comment period. For example, in August, 2022, BOEM published in the FR an RFI for leasing tracts in federal waters [39]. An RFI serves three purposes [40], to provide (i) a description of the proposed project and the requested lease area for public review; (ii) interested parties an opportunity to express interest in competing for an EEZ lease; (iii) all parties with opportunity to comment. BOEM's primary uses of the information and comments received in response to an RFI are [40] to identify whether competitive interest exists (see step 3 below) and to further refine proposed lease area(s) based on environmental analysis, public input on potential environmental consequences, National Environmental Policy (NEPA) analysis, and potential conflicts with other ocean users.

NEPA analysis is conducted by BOEM's Office of Environmental Programs, with objectives being to assess the potential environmental consequences of developing the offshore wind energy facilities. To satisfy NEPA for offshore wind projects, BOEM conducts comprehensive environmental reviews, including preparing Environmental Assessments (EAs) or Environmental Impact Statements (EISs), consults with stakeholders and other agencies, and develops mitigation measures to address potential impacts. Additional consultations [41] may occur with the National Marine Fisheries Service, the U. S. Fish and Wildlife Service under the Endangered Species Act, the Magnuson-Stevens Fishery Conservation and Management Act, and Section 106 of the National Historic Preservation Act.

9a-3.3 Determine competitive interest

BOEM's process for establishing a lease differs depending on whether interest is non-competitive, i.e., from a single qualified entity, or competitive, i.e., from multiple qualified entities.

9a-3.3.1 Non-competitive

If the interest is non-competitive, then in this case, after receiving an unsolicited lease request, BOEM may elect to issue a request for competitive interest (RFCI) to determine if a competitive lease sale is warranted. Reference [42] provides an example of a recent RFCI for the Gulf of Maine. If additional indications of interest are received, the situation shifts to the competitive lease sale below. Otherwise, following BOEM evaluation, if approved, BOEM will make a direct award, meaning that BOEM will award a lease directly to the developer rather than through a competitive bidding process.

9a-3.3.2 Competitive

On the other hand, if the interest is competitive, i.e., if BOEM receives multiple indications of competitive interest from qualified entities, it may decide to move forward with the issuance of a lease or ROW grant using competitive procedures. In this case, BOEM uses a competitive auction process, following execution of the following four steps:

i. *Call for Information and Nominations*: BOEM begins by identifying potential areas for wind energy development, often starting with a *Call* (for Information and Nominations) to solicit input from various parties, including industry, the public, and government agencies on site conditions. The *Call*, normally following an RFI, initiates the competitive leasing process for offshore wind energy development in a specific area, known as the *Call Area*. BOEM uses this information to determine if there is sufficient commercial interest in leasing the area for wind energy development. BOEM has issued Calls for Information and Nominations for the Central Atlantic [43, 44], Oregon [45], Gulf of Maine [46], Gulf of Mexico [47], and Guam [48].

ii. *Area Identification*: From [49],

> "Area identification is the process by which BOEM delineates one or more OCS areas for leasing consideration and environmental analysis if the areas appear appropriate for renewable energy development. This process is based on an area's relevant attributes, such as other uses of the area, environmental factors or characteristics, stakeholder comments, industry nominations, feasibility for development, and other relevant information."

BOEM consults with interested parties during this process, including appropriate Federal agencies, State and local governments, federally recognized Tribes, Alaska Native Claims Settlement Act corporations, and other interested parties. Although it is frequent that considered areas are nominated by respondents to a Call, BOEM may consider other areas they deem appropriate for leasing. For the identified areas, BOEM evaluates the potential effects of leasing the identified areas on the human, marine, and coastal environments; the feasibility of development; and potential measures, including lease stipulations, to mitigate potential adverse impact. Such measures are identified and refined through the area identification process, as well as through environmental review and consultations; they are published for comment in the Proposed Sale Notice.

iii. *Proposed Sale Notice*: As stated in [50], the proposed sale notice (PSN) is an announcement of BOEM's intention to conduct an auction for prospective lease areas. A PSN sets forth provisions and information concerning the proposed auction and lease and invites stakeholder comments. BOEM has issued PSNs for the Gulf of Maine [51] including eight lease areas offshore Maine, Massachusetts, and New Hampshire; the Central Atlantic [52] including one area offshore Delaware and Maryland, and one area offshore Virginia; the Gulf of Mexico [53] located in the Louisiana Coast Region (Lake Charles) and the Texas Coast Region (Galveston I and Galveston II); and Oregon [54] including two areas offshore the Oregon coast.

iv. *Final Sale Notice*: As stated in [50], the final sale notice (FSN) sets forth final information concerning a competitive auction to issue offshore leases and right-of-way grants for renewable energy projects. The FSN provides the final terms and conditions for a lease sale, including the date, time, and location for the sale itself [55]. The FSN will also include a list of the companies that have legally, technically, and financially qualified to participate in the lease sale. BOEM publishes the FSN, or a notice of its availability, in the FR. BOEM has issued FSNs for the Gulf of Maine [56], the Central Atlantic [57], and the Gulf of Mexico [58], and Oregon [59].

9b-4 BOEM lease auctions

Wind lease sales occur through lease auctions organized by BOEM. BOEM held its first competitive federal offshore commercial wind lease sales in July 2013, auctioning off nearly 165,000 acres for wind energy development off the coasts of Massachusetts and Rhode Island [60] and has held many others since that time, including for Maryland in 2014 [61], Massachusetts [62] and New Jersey [63] in 2015, New York in 2016 [64], North Carolina in 2017 [65], Massachusetts in 2018 [66], in 2022 New York Bight area (New York and New Jersey) [67, 68], and the Gulf of Mexico in 2023 [69].

BOEM uses an ascending clock auction (also known as a Japanese forward auction, which is a special form of an English auction) [70], where the price increases automatically at regular intervals, and bidders must accept the price or drop out, with the last remaining bidder winning the auction. BOEM sets the initial bid amount, called the opening price. The opening price, in dollars/acre, is the initial bidding floor; its selection is based on BOEM's assessment of the area's value and expected interest in it. The auction occurs over bidding rounds; in each round, BOEM "ticks" up the auction price like a clock. A percentage increase is applied to the previous round's price corresponding to the level of demand and the Bids signal whether a bidder is "in" or "out" at the round's announced price [71].

Each round's price and number of bidders are posted publicly. The auction concludes when each lease area has only one remaining bidder, the one willing to pay the most for the lease area. If all bidders from the previous round drop out from one round to the next, an "exit-bid" price is used as a tie-breaker to determine the winner; here, bidders are required to submit the “exit bid” price in the round they leave the auction. The exit bid price must fall between the previous and current round’s prices; the tie-breaker is implemented by identifying the winner as the bidder with the highest exit bid. Figure 9b - 6 illustrates an ascending clock example with three bidders that require a tie-breaker at the end [71]. The illustration of Figure 9b - 6 is called “single lot” because the lease area is considered to be a single lot, i.e., the lease area is not divided into multiple lots.

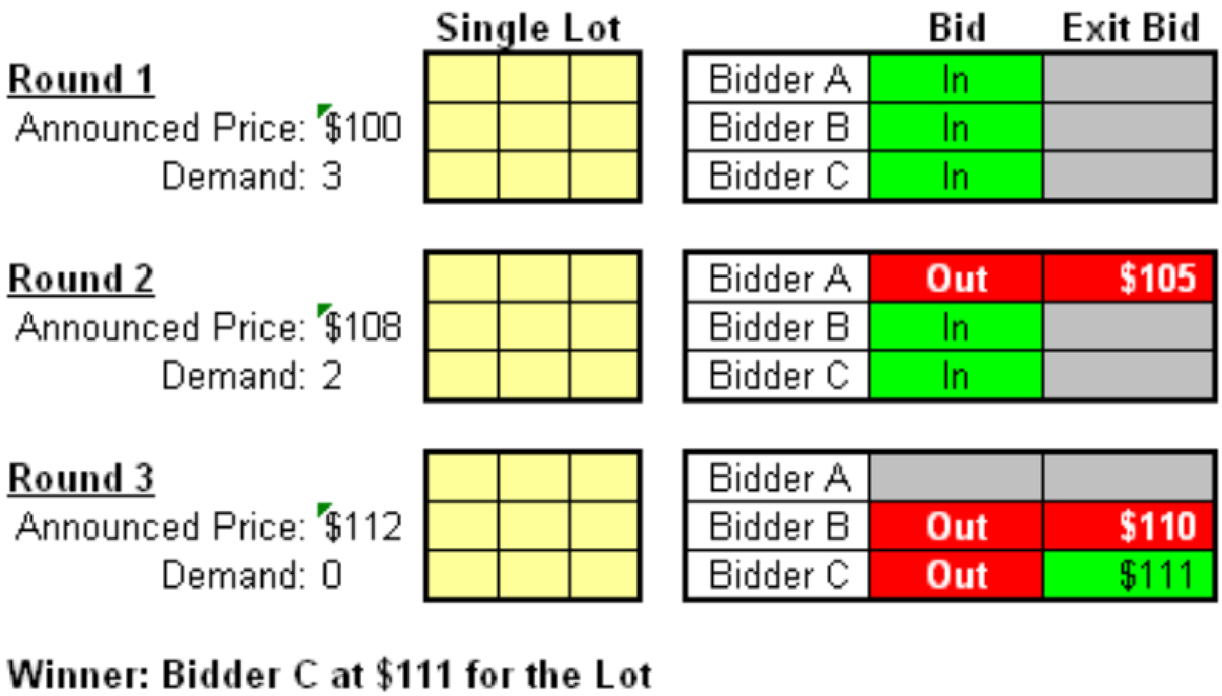

Figure 9b - 6: Ascending clock auction example with tie-breaker at end [71]

BOEM also conducts multi-lot ascending clock auctions where a larger lease area is divided into a set of individual lots for sale. As indicated in [71], bidding on all of the lots occurs at the same time over multiple rounds; the auction is therefore called a “simultaneous ascending clock auction” (SACA). At each round, bidders indicate a “yes” for each lot in the set of contiguous lots in which they have interest at the round’s price. If the number of bidders interested in any lot is more than one, another round occurs; otherwise, the auction closes. BOEM ticks up the price for each lot at the outset of each round. Bidders may reduce, but not increase, the number of lots they bid on from one round to the next.

BOEM’s auctions allow multi-factor bids, where monetary and non-monetary factors are used to determine the outcome of a lease sale, rather than relying on the highest cash bid. The multi-factor auction format aims to incentivize development of the offshore wind industry while also addressing potential environmental and social impacts. Non-monetary factors are accounted for via bidding credits. For example, in the Carolina Long Bay auction, a bidding credit was awarded to participants providing documentation indicating they would contribute to workforce training [72]. BOEM has also used factors that indicate a bidder has a higher probability of success in developing an offshore wind project on the OCS, by asking participants to respond to questions like [71] “Do you currently hold a firm financial commitment for the sale of at least 100 MW of power from a proposed offshore wind development in the lease sale area?" and "Have you completed installation of a meteorological measurement tower on a BOEM limited lease located within the lease sale area?"

Following conclusion of the auction [68], the US Department of Justice (DOJ) has 30 days to conduct an auction antitrust review, after which BOEM informs each auction winner how to execute the lease. Within 10 business days of receiving the lease, auction winners must post financial assurances, pay any outstanding balance of their bid deposit, and sign and return the lease. Once BOEM has received the signed leases and verified that all other required materials have been received, BOEM executes the leases.

The 2022 New York Bight auction is the largest US offshore wind lease auction ever at a total lease amount of $4.37 billion, 461,326 developable acres, and 5.6 GW of intended generating capacity [68]. The wind energy areas of interest in this auction are illustrated in Figure 9b - 7 [68]. A timeline proposed by the Biden Administration for subsequent auctions in 2024 and beyond are illustrated in Figure 9b - 8 [26].

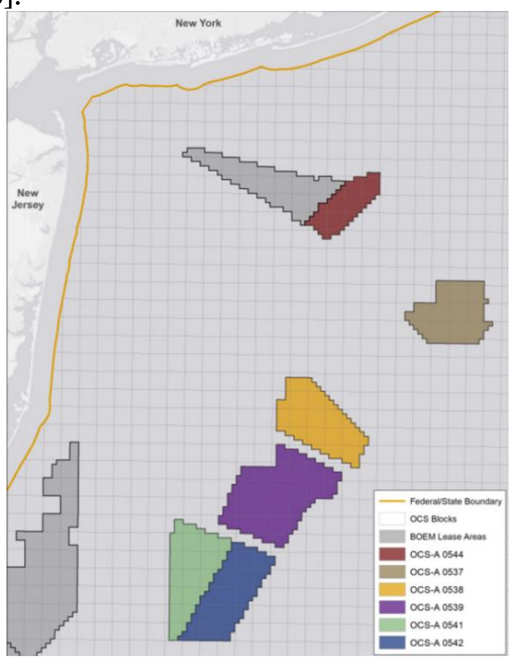

Figure 9b - 7: Wind energy areas for New York Bight Auction [68]

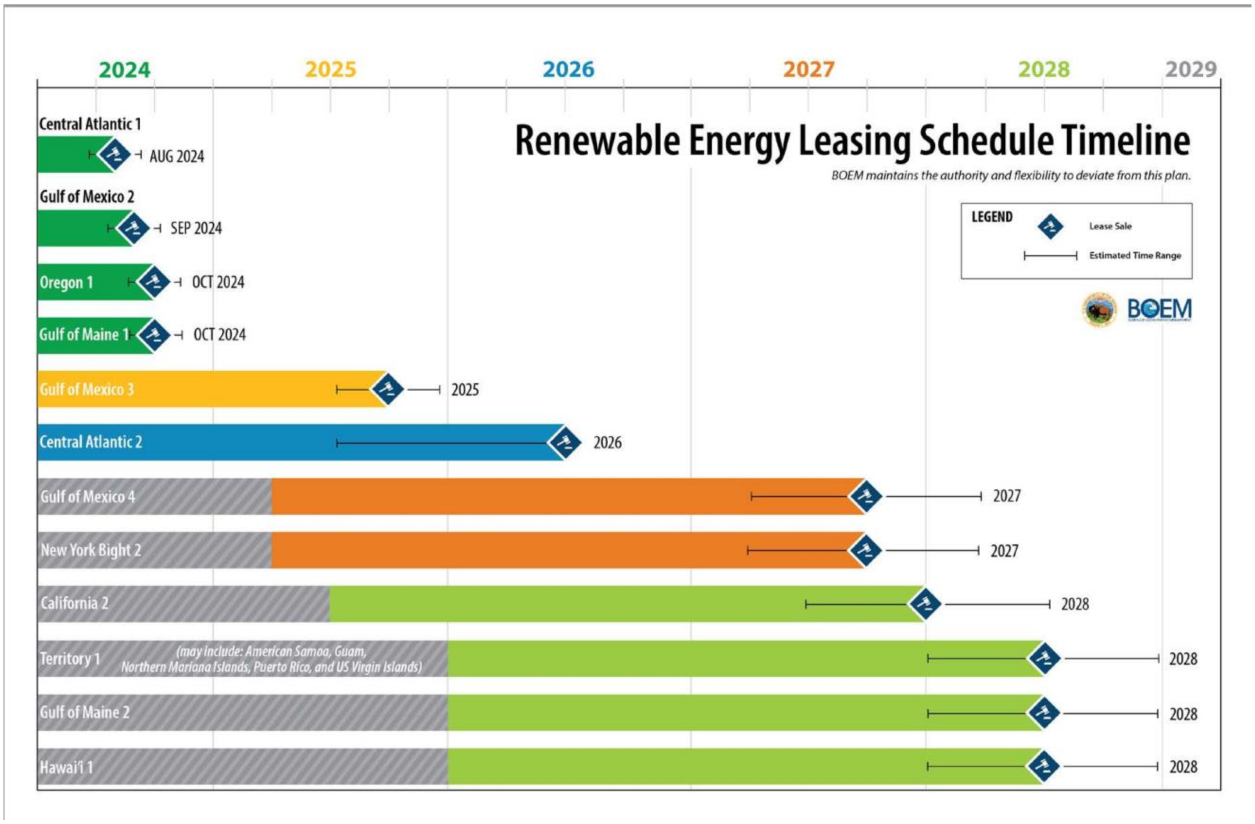

Figure 9b - 8: Recent & planned future offshore wind auctions in the US [26]

INDUSTRY INSIGHT

BOEM's planning and analysis, together with its lease auctions, are well illustrated by their efforts in the Gulf of Maine. Figure 9b - 9 provides the first page of the Gulf of Maine's RFI (left, [39]) and the first page of the Gulf of Maine's RFCI (right [42]). Figure 9b - 10 provides the first page of the Gulf of Maine's *Call* (left [46] and the first page of the Gulf of Maine's Proposed Sale Notice (right [51]). Figure 9b - 11 provides the first page of the Gulf of Maine's Final Sale Notice (left [55]) and a summary of the Gulf of Maine's auction results (right [35]).

Request for Interest (RFI) in Commercial Leasing for Wind Energy Development on the Gulf of Maine Outer Continental Shelf (OCS)

A Notice by the Ocean Energy Management Bureau on 08/19/2022

PUBLISHED DOCUMENT: 2022-17921 (87 FR 51129)

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DOCUMENT HEADINGS

Department of the Interior
Bureau of Ocean Energy Management
[Docket No. BOEM-2022-0040]

AGENCY:

Bureau of Ocean Energy Management, Interior.

ACTION:

Request for interest and comments.

SUMMARY:

The Bureau of Ocean Energy Management (BOEM) issues this RFI to assess interest in, and to invite public comment on, possible commercial wind energy leasing on the Gulf of Maine OCS. BOEM will consider information received in response to this RFI to determine whether to schedule a competitive lease sale or to issue a noncompetitive lease for any portion of the area described in this RFI (RFI Area). Those interested in leasing within the RFI Area for a commercial wind energy project should provide detailed and specific information described in the section of this RFI entitled "Required Information for Indication of Commercial Interest." BOEM also invites all interested and potentially affected parties to comment and provide information—including information on environmental issues and concerns—that may be useful in the consideration of the RFI Area for commercial wind energy leases. Developers and those interested in providing public comments and information regarding site conditions, resources, and multiple uses in close proximity to, or within, the RFI Area should provide information requested in the section of this RFI entitled "Requested Information from Interested or Affected Parties." BOEM will process the information received in response to this RFI to determine if there is competitive interest to develop renewable energy on the OCS, understand ocean uses, identify conflicts, and deconflict, as appropriate. See the section of this RFI entitled "BOEM's Planning and Leasing Process."

DATES:

Submissions indicating your interest in or providing comments on commercial leasing within the RFI Area must be received no later than October 3, 2022. BOEM may not consider late submissions.

Research Lease on the Outer Continental Shelf (OCS) in the Gulf of Maine, Request for Competitive Interest (RFCI)

A Notice by the Ocean Energy Management Bureau on 08/19/2022

PUBLISHED DOCUMENT: 2022-17922 (87 FR 51134)

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DOCUMENT HEADINGS

Department of the Interior
Bureau of Ocean Energy Management
[Docket No. BOEM-2022-0041]

AGENCY:

Bureau of Ocean Energy Management (BOEM), Interior.

ACTION:

Requests for competitive interest and public comment.

(print page 51135)

SUMMARY:

This notice describes the State of Maine's proposal for an OCS lease in the Gulf of Maine to conduct wind energy research activities; invites indications of interest in acquiring a commercial wind energy lease within an area of approximately 68,320 acres identified in the "Description of the RFCI Area" section of this notice, which includes the area identified by Maine (hereinafter, the "RFCI Area"); and solicits public input regarding Maine's proposal, the potential for commercial leasing in the RFCI Area, the potential resultant environmental impacts, and other uses of the area.

DATES:

Submissions indicating your interest in acquiring a commercial wind energy lease within the RFCI Area as well as all other comments and information, must be received by BOEM no later than October 3, 2022. BOEM may not consider late submissions.

Figure 9b - 9: Gulf of Maine request for interest (left [39]) and request for competitive interest (right [42])

Commercial Leasing for Wind Power Development on the Gulf of Maine Outer Continental Shelf (OCS)-Call for Information and Nominations

A Notice by the Ocean Energy Management Bureau on 04/26/2023

PUBLISHED DOCUMENT: 2023-08670 (88 FR 25427)

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DOCUMENT HEADINGS

Department of the Interior
Bureau of Ocean Energy Management
[Docket No. BOEM-2023-0025]

AGENCY:

Bureau of Ocean Energy Management (BOEM or we), Interior.

ACTION:

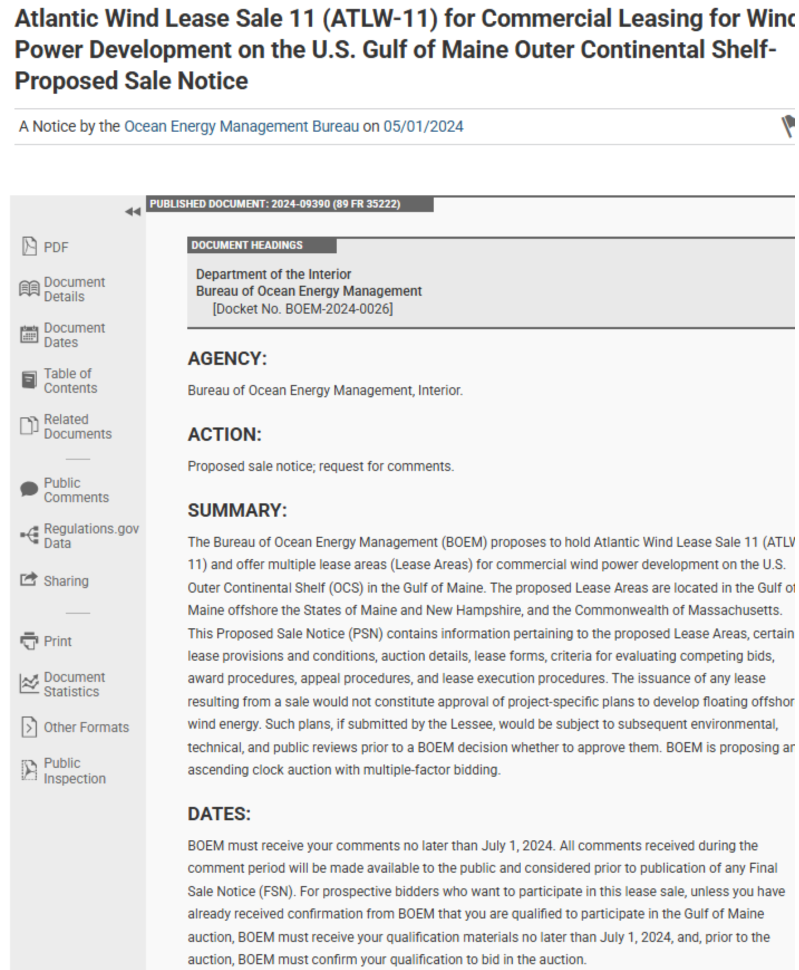
Call for information and nominations; request for comments.

SUMMARY:

This call for information and nominations (Call or notice) invites public comment on, and assesses interest in, possible commercial wind energy leasing on the U.S. OCS in the Gulf of Maine. On August 1 2022, BOEM initiated the competitive leasing process by issuing a request for interest (RFI) to solicit indications of interest and other information for BOEM to determine whether competitive interest existed for scheduling lease sales. This Call represents the next step in the competitive leasing process The Call area is identified and described in section 6 below. Those interested in providing comments or information regarding site conditions, resources, and multiple uses in close proximity to or within the Call area should provide the information requested in section 7, "Requested Information from Intereste or Affected Parties," under the "Supplementary Information" heading of this Call. Those interested in leasing within the Call area for a commercial wind energy project should provide the information described in section 8, "Required Nomination Information," under "Supplementary Information." BOEM may or may not offer a lease for a commercial offshore wind energy project within the Call area after further government consultations, public participation, and environmental analyses.

DATES:

Your interest in or comments on commercial leasing within the Call area must be received by BOEM no later than June 12, 2023. Late submissions may not be considered.



Atlantic Wind Lease Sale 11 (ATLW-11) for Commercial Leasing for Winc Power Development on the U.S. Gulf of Maine Outer Continental Shelf-Proposed Sale Notice

A Notice by the Ocean Energy Management Bureau on 05/01/2024

PUBLISHED DOCUMENT: 2024-09390 (89 FR 35222)

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DOCUMENT HEADINGS

Department of the Interior
Bureau of Ocean Energy Management
[Docket No. BOEM-2024-0026]

AGENCY:

Bureau of Ocean Energy Management, Interior.

ACTION:

Proposed sale notice; request for comments.

SUMMARY:

The Bureau of Ocean Energy Management (BOEM) proposes to hold Atlantic Wind Lease Sale 11 (ATLV 11) and offer multiple lease areas (Lease Areas) for commercial wind power development on the U.S. Outer Continental Shelf (OCS) in the Gulf of Maine. The proposed Lease Areas are located in the Gulf of Maine offshore the States of Maine and New Hampshire, and the Commonwealth of Massachusetts. This Proposed Sale Notice (PSN) contains information pertaining to the proposed Lease Areas, certain lease provisions and conditions, auction details, lease forms, criteria for evaluating competing bids, award procedures, appeal procedures, and lease execution procedures. The issuance of any lease resulting from a sale would not constitute approval of project-specific plans to develop floating offshor wind energy. Such plans, if submitted by the Lessee, would be subject to subsequent environmental, technical, and public reviews prior to a BOEM decision whether to approve them. BOEM is proposing ar ascending clock auction with multiple-factor bidding.

DATES:

BOEM must receive your comments no later than July 1, 2024. All comments received during the comment period will be made available to the public and considered prior to publication of any Final Sale Notice (FSN). For prospective bidders who want to participate in this lease sale, unless you have already received confirmation from BOEM that you are qualified to participate in the Gulf of Maine auction, BOEM must receive your qualification materials no later than July 1, 2024, and, prior to the auction, BOEM must confirm your qualification to bid in the auction.

Figure 9b - 10: Gulf of Maine Call for information & nominations (left [46]); proposed sale notice (right [51])

Atlantic Wind Lease Sale 11 for Commercial Leasing for Wind Power Development on the U.S. Gulf of Maine Outer Continental Shelf-Final Sale Notice

A Notice by the Ocean Energy Management Bureau on 09/17/2024

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PUBLISHED DOCUMENT: 2024-21081 (89 FR 76132)

DOCUMENT HEADINGS

Department of the Interior
Bureau of Ocean Energy Management
[Docket No. BOEM-2024-0026]

AGENCY:

Bureau of Ocean Energy Management, Interior.

ACTION:

Final sale notice; request for comments.

SUMMARY:

This Final Sale Notice (FSN) contains information pertaining to the areas available for commercial wind power leasing during Atlantic Wind Lease Sale 11 (ATLW-11) on the U.S. Outer Continental Shelf (OCS) in the Gulf of Maine. Specifically, this FSN details certain provisions and conditions of the leases, auction details, the lease form, criteria for evaluating competing bids, and procedures for award, appeal, and lease execution. The Bureau of Ocean Energy Management (BOEM) will offer eight leases for sale using an ascending clock auction with multiple-factor bidding: Lease OCS-A 0562, OCS-A 0563, OCS-A 0564, OCS-A 0565, OCS-A 0566, OCS-A 0567, OCS-A 0568, and OCS-A 0569 (lease areas). The first two lease areas (lease areas OCS-A 0562 and OCS-A 0563) comprise the North Region, and the remaining six lease areas comprise the South Region. Bidders are limited to bidding on no more than two lease areas at a time, and may not include in their bid more than one lease area in the North Region at a time. BOEM will use the BOEM Auction System for the lease sale. The lease areas are in the previously identified wind energy areas located in the Gulf of Maine offshore the States of Maine and New Hampshire and the Commonwealth of Massachusetts. The issuance of any lease resulting from this sale will not constitute approval of project-specific plans to develop offshore wind energy. Such plans, if submitted by the lessee, will be subject to environmental, technical, and public reviews prior to a BOEM decision on whether the proposed activity should be authorized.

DATES:

BOEM will hold an online mock auction for potential bidders starting at 9:00 a.m. Eastern Daylight Time (EDT) on October 24, 2024. The monetary auction will be held online and will begin at 9:00 a.m. EDT on October 29, 2024. Additional details are provided in the section entitled, "Deadlines and Milestones for Bidders."

Gulf of Maine Offshore Wind Lease Sale

On October 29, 2024, the Department of Interior announced the results of an offshore wind energy lease sale on the Outer Continental Shelf (OCS) in the Gulf of Maine. The auction resulted in two provisional winners on four lease areas and over $21.9 million in winning bids.

Avangrid Renewables, LLC won Lease **OCS-A 0564** at $4,928,250, which consists of 98,565 acres and Lease **OCS-A 0568** at $6,244,850, which consists of 124,897 acres. Both lease areas are approximately 29.5 nautical miles (nm) from Massachusetts.

Invenergy NE Offshore Wind, LLC won Lease **OCS-A 0562** at $4,892,700, which consists of 97,854 acres and is approximately 46.2 nm from Maine and Lease **OCS-A 0567** at $5,889,000 which consists of 117,780 acres is approximately 21.6 nm from Massachusetts.

Together, the leased areas have the potential to power more than 2.3 million homes with clean energy.

Background

There are five leases in the Gulf of Maine.

- State of Maine Research Lease (OCS-A 0553)
- Invenergy NE Offshore Wind, LLC (OCS-A 0562)
- Avangrid Renewables, LLC (OCS-A 0564)
- Invenergy NE Offshore Wind, LLC (OCS-A 0567)
- Avangrid Renewables, LLC (OCS-A 0568)

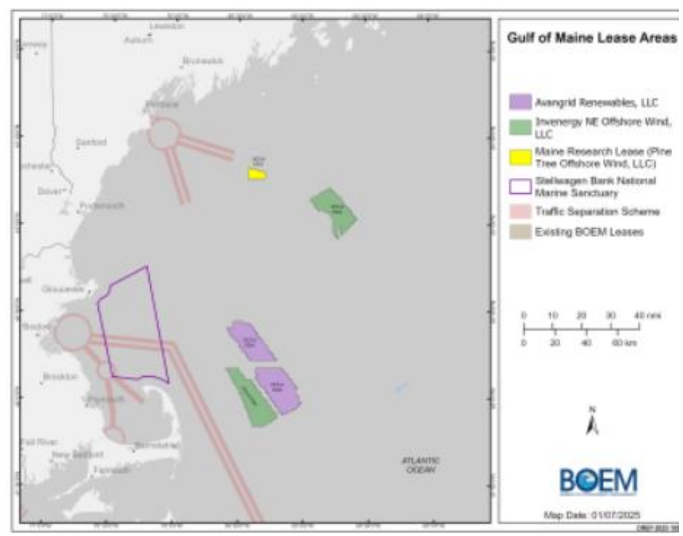

Figure 9b - 11: Gulf of Maine final sale notice (left [56]) and auction results (right [35])

9b-5 Transmission development

There are three entities that have significant influence on offshore transmission development: the Federal government; state and local governments; and regional transmission organizations (RTOs) and utilities, as addressed in Subsections 9a-5.1, 9a-5.2, and 9a-5.3, respectively. In addition, we extend Section 9a-5.3 to describe how these various processes are influenced by offshore topology and as a result, whether the transmission is HVAC or HVDC or both [73, 74].

9a-5.1 Federal government

The Secretary of the Interior has authority to lease areas in the outer continental shelf for offshore wind energy or the transmission necessary to serve it, as stated in OCSLA, section 1337(p)(1), where it says that the Secretary, "in consultation with the Secretary of the Department in which the Coast Guard is operating and other relevant departments and agencies of the Federal Government, may grant a lease, easement, or right-of-way on the outer Continental Shelf for activities not otherwise authorized in this subchapter…if those activities…(C) produce or support production, transportation, storage, or transmission of energy from sources other than oil and gas." Furthermore, anyone who wants to develop offshore wind or the transmission necessary to serve it must obtain a lease, easement, or right ow way (ROW) from the Secretary of the Interior, as stated in OCSLA Section 585.104, where it says, "Except as otherwise authorized by law, it is unlawful for any person to construct, operate, or maintain any facility to produce, transport, or support generation of electricity or other energy product derived from a renewable energy resource on any part of the OCS, except in accordance with the terms of a lease, easement, or ROW issued under the OCS Lands Act."

OCSLA provides that there are two paths for developing transmission for offshore wind energy:

A. *Transmission as part of an offshore wind lease*: OCSLA Section 585.200(b) says that "A lease issued under this part confers on the lessee the right to one or more project easements without further competition for the purpose of installing gathering, transmission, and distribution cables; pipelines; and appurtenances on the OCS as necessary for the full enjoyment of the lease," and that "(1) You must apply for the project easement as part of your COP [Construction and operations plan] or GAP [General activities plan], as provided under subpart G of this part; and (2) BOEM will incorporate your approved project easement in your lease as an addendum." There are two key issues when using this path:
   a. *Landfalls and Points of Interconnections (POIs)*: The lessee works with regional and state entities and utilities to determine appropriate landfall(s) and POI(s). A grid connection study will normally be required by the appropriate RTO. In that study, the RTO determines the upgrades necessary for interconnection; the lessee is responsible for paying for those upgrades.
   b. *Easement to shore*: The transmission cables will necessarily have to traverse state waters, and so authorization by the state is necessary, the details of which must be included in the Construction and Operations Plan (COP). The easement through state waters is granted when the COP is approved; although the state water easement must be granted by the state, the COP approval is obtained from BOEM.

B. *Transmission under a ROW grant*: OCSLA Section 585.300 states that "(a) A ROW [right of way] grant authorizes the holder to install on the OCS cables, pipelines, and associated facilities that involve the transportation or transmission of electricity or other energy product

> from renewable energy projects. (b) A RUE [right-of-use and easement] grant authorizes the holder to construct and maintain facilities or other installations on the OCS that support the production, transportation, or transmission of electricity or other energy product from any renewable energy resource."

9a-5.2 State and local government

The 1972 federal Coastal Zone Management Act (CZMA) [75] defines the coastal zone as "the coastal waters (including the lands therein and thereunder) and the adjacent shorelands (including the waters therein and thereunder), strongly influenced by each other and in proximity to the shorelines of the several coastal states, and includes islands, transitional and intertidal areas, salt marshes, wetlands, and beaches." CZMA gave the states the authority to manage the coastal zone, as indicated below [76]:

> "The key to more effective protection and use of the land and water resources of the coastal zone is to encourage the states to exercise their full authority over the lands and waters in the coastal zone by assisting the states, in cooperation with Federal and local governments and other vitally affected interests, in developing land and water use programs for the coastal zone, including unified policies, criteria, standards, methods, and processes for dealing with land and water use decisions of more than local significance."

As a result, state agencies must be involved in assessing and approving all facilities in state waters, at landfalls, and on shore between landfalls and POIs. However, there are significant variations from one state to another in terms of which agencies must be involved. Table 9b - 1 summarizes the agencies involved in permitting offshore wind needs for most states along the US Atlantic seaboard.

Table 9b - 1: Summary of agencies involved in offshore wind permitting in various states

	New York [77]	New Jersey	Mass	Rhode Island	Maine	Connecticut	Virginia	North Carolina
Permit for transmission system connecting offshore wind to electricity grid	NY Public Service Commission (PSC)	New Jersey Board of Public Utilities (NJBPU) [78]	Energy Facilities Siting Board (EFSB) [79]	Rhode Island Energy Facility Siting Board (EFSB) [80]	Maine Public Utilities Commission (MPUC) [81]	CT Siting Council (CSC) [82]	VA State Corporation Commission [83]	NC Dept of Env Quality (DEQ) [84]
Permits for coastal environmental impacts	NY Dept of Environmental Conservation (DEC), PSC	New Jersey Department of Environmental Protection (NJDEP) [85]	Massachusetts Office of Coastal Zone Management (CZM) [86]	Rhode Island Coastal Resources Management Council (CRMC) [87]	Maine Dept of Env Protection (DEP) [88]	CT Dept of Energy & Env. Protection (DEEP) [82]	VA Dept of Env. Quality [89]	NC Dept of Env Quality (DEQ) Division of Coastal Management (DCM) [90]
Easement for underwater cables	NY Office of General Services (OGS)	New Jersey Board of Public Utilities [91]	Mass Dept of Env Protection [92]	Rhode Island CRMC [87]; Rhode Island General Assembly [93]	Bureau of Parks & Lands Dept of Conservation [94]	CT Dept of Energy& Env Protection (DEEP) [95]	VA Marine Resources Commission (VMRC) [96]	NC Dept of Administration [97]
Federal Consistency Review	NY Dept of State (DOS)	New Jersey Dept of Env. Protection (NJDEP), Div. of Land Rsrce Protection (DLRP) [98]	Massachusetts Office of Coastal Zone Management (CZM) [86]	Rhode Island Coastal Resources Management Council (CRMC) [99]	Maine Dept of Marine Resources (DMR) [100]	CT Dept of Energy & Env Protection (DEEP) [101]	VA Dept of Env. Quality [102]	NC Dept of Env Quality (DEQ) [84]
Permit for work on state-owned roads	NY Department of Transportation (NYDOT)	Local governments & NJBPU [103]	Mass Dept of Transp (massDOT) [104]	Rhode Island Dept of Transp (RIDOT) [105]	Maine Dept of Transp (Maine DOT) [106]	CT Dept of Transp (CTDOT) [107]	VA Dept of Transp (VDOT) [108]	NC Dept of Transp (NCDOT) [109]
Other state organizations with permitting control/influence	NY State Energy Research & Development Authority (NYSERDA)[110]	New Jersey Economic Development Authority (NJEDA) [111]	Mass Dept of Energy Resources (DOER) [112]	Rhode Island Dept of Env. Management (RIDEM) [113]	Maine Dept of Marine Resources (DMR) [114]	Connecticut Wind Collaborative [115]	Virginia Dept of Energy [116]	NC Taskforce for Offshore Wind Economic Strategies (NC Towers) [117]

9a-5.3 Regional transmission organizations and utilities

The task of designing the transmission additions necessary to integrate offshore wind to the existing grid lies with the wind plant developer(s) together with the regional transmission operator(s) (RTO(s)) and transmission owner(s) responsible for the grid to which the offshore wind will be interconnected. The level of participation of each of these entities depends on the nature of the intended offshore transmission topology.

9a-5.3.1 Offshore topological influence

By "offshore topology," we refer strictly to the offshore transmission system topology; it is to this system that a wind plant's collector substation connects, where the collector substation is an offshore hub to which the wind plant's collector circuits connect.

There are many possible offshore network topologies, but the spectrum tends to be bound by two extremes: lead-line and backbone. The lead-line design connects each wind plant with its own transmission directly to shore, and so there are as many connections to shore as there are wind plants. In this case, the transmission can be either AC or DC, but generally the most economically attractive solution is AC. On the other hand, the backbone design connects each wind plant with a backbone transmission line running parallel to the coast. The backbone transmission line is then connected to shore using a limited number of transmission lines. In this case, because the backbone transmission is typically of significant length, line charging inhibits use of an AC transmission solution, and so backbone designs are typically DC. These two designs are illustrated in Figure 9b - 12.

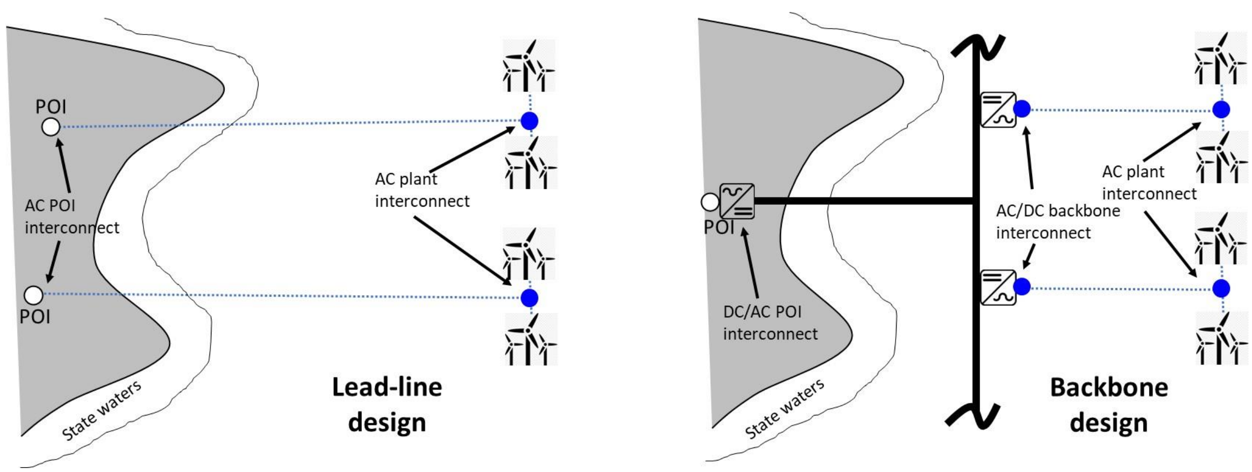

Figure 9b - 12: Lead-line design (left) and backbone design (right)

We observe in Figure 9b - 12 that in both designs, there are two wind plants, one in the north and one in the south, with an AC collector substation for each. However, whereas the lead-line design has two connections to shore, the backbone design has only one connection to shore. On the other hand, the lead-line design needs only four AC substations (two offshore and the two onshore POIs), whereas the backbone design needs three AC substations (two offshore and one POI).

This situation is further illustrated in Figure 9b - 13, where the goal is to interconnect five wind plants to shore. The lead-line design results in five separate connections to shore, whereas the backbone design results in three separate connections to shore.

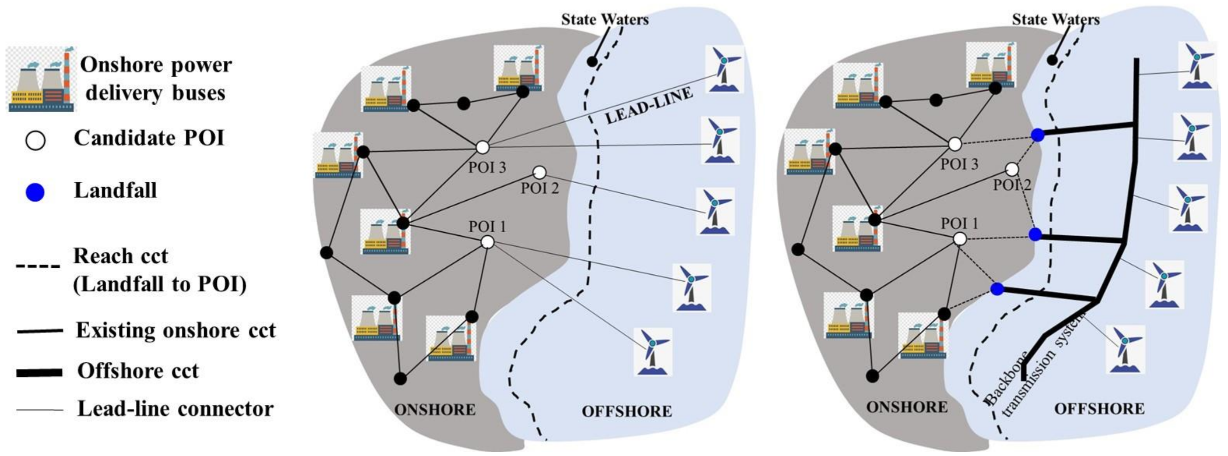

Figure 9b - 13: Lead-line design (left) and backbone design (right)

The implication of the illustrations in Figure 9b - 12 and Figure 9b - 13 is that, when designing for a small number of wind plants, the task of siting, approving, and constructing the transmission to shore should favor the lead-line design. But when designing for a large number of wind plants, this same task may well favor the backbone design given that it results in fewer connections to shore, but with higher capacity (assuming reliability criteria can be satisfied for loss of one of the landfalls[2]).

9a-5.3.2 Organizational participation in transmission design

Lead-line designs are generally driven by the wind plant developer, who coordinates their design with the transmission owner and the RTO responsible for the grid to which they desire to connect. This is because the offshore topology is relatively simple. In this case, it is likely that study effort to test and refine the design would result from the standard RTO transmission planning process where the offshore wind farms are entered into the RTO's Generation Interconnection Queue (GIQ) and ultimately included in a transmission planning study that results in regional transmission project recommendations. Figure 9b - 14 [118] provides a high-level illustration of the planning process carried out by NYISO, which is the RTO for the state of New York. Developers of a lead-line transmission project intended to interconnect an offshore wind plant to the NYISO grid would need to enter their project into the GIQ, provide stakeholder input, and consider local transmission owner plans before inclusion in the NYISO Comprehensive System Planning Process (CSPP), obtaining transmission plans via NYISO's regional transmission project recommendations (see Figure 9b - 14).

[2] Regions in the Northeast US require that interconnection points satisfy the single source contingency limit (SSCL). The SSCL is the maximum amount of power a power grid can lose due to the sudden loss of a single large source of power generation and remain stable. The offshore grid must be designed so that landfall capacities are each below the SSCL; typically, these SSCLs are between 1000 and 2500 MW. Achieving landfall capacities beyond this range can be achieved by implementing remedial action schemes that exert control (e.g., reducing the offshore generation) for loss of the landfall connection.

Consideration of multiple offshore wind plants connected to shore via a backbone transmission topology might flow through the process in this same way if the interconnections to shore are entirely contained within the NYISO grid. If, however, the backbone corridor included interconnections with the ISO-NE grid to the north and/or the PJM grid to the south, then the analysis would flow through the Interregional Transmission Planning path shown in Figure 9b - 14 and would then include analysis by the concerned RTO.

Planning processes for other RTOs, e.g., ISO-NE and PJM, are illustrated and described in [118]. Although these processes differ from that of NYISO in the individual steps, the essentials of the input and output information and the intervening paths, are the same as that shown in Figure 9b - 14.

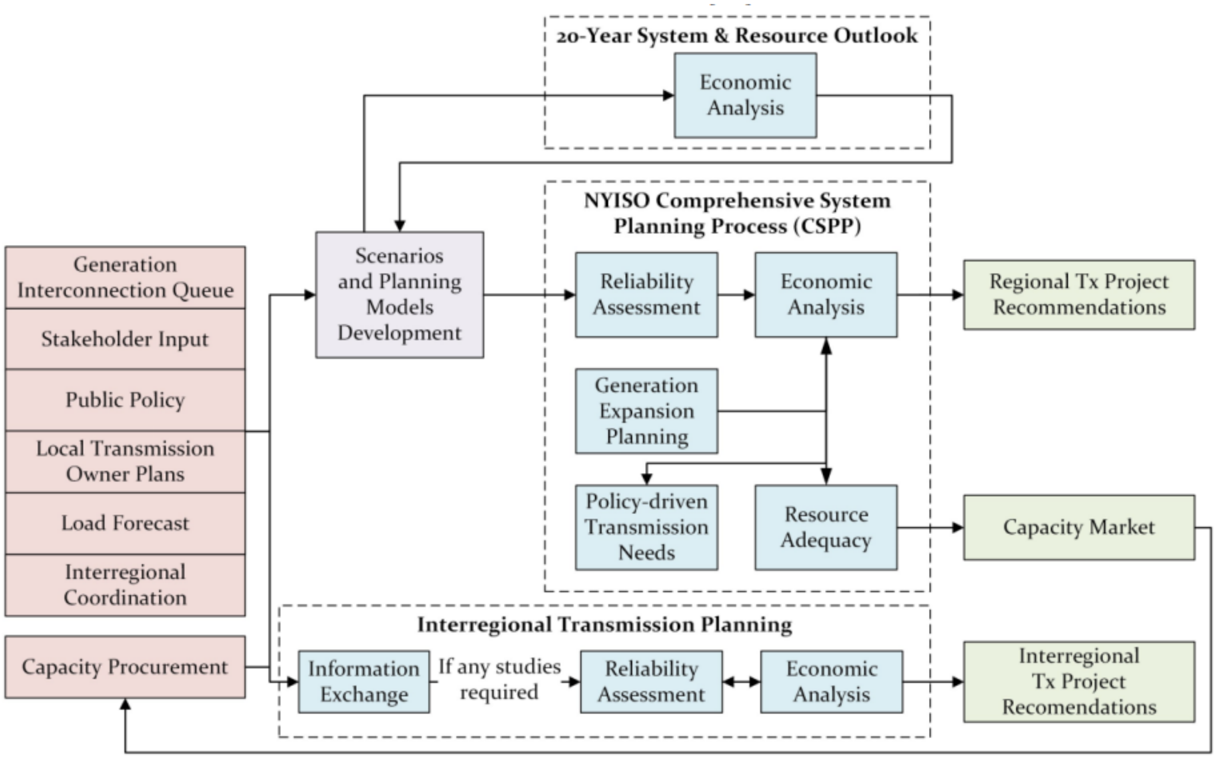

Figure 9b - 14: NYISO Planning Process [118]

It is most likely that future offshore transmission topologies designs will be hybrid, i.e., a mix of both lead-line and backbone topologies, likely necessitating both regional and interregional planning processes. In addition, it is possible that an offshore transmission system could span several regions, thus requiring a multiregional process. Such designs have been proposed in the Atlantic Offshore Wind Energy Study as illustrated in on the left of Figure 9b - 15 [119]. And in a sister study led by Tufts University, a multiregional backbone design was developed (lead-line topologies were not used), as illustrated on the right of Figure 9b - 15 [120]. Such designs may motivate the development of a multiregional body to facilitate its design and support its operation and maintenance.

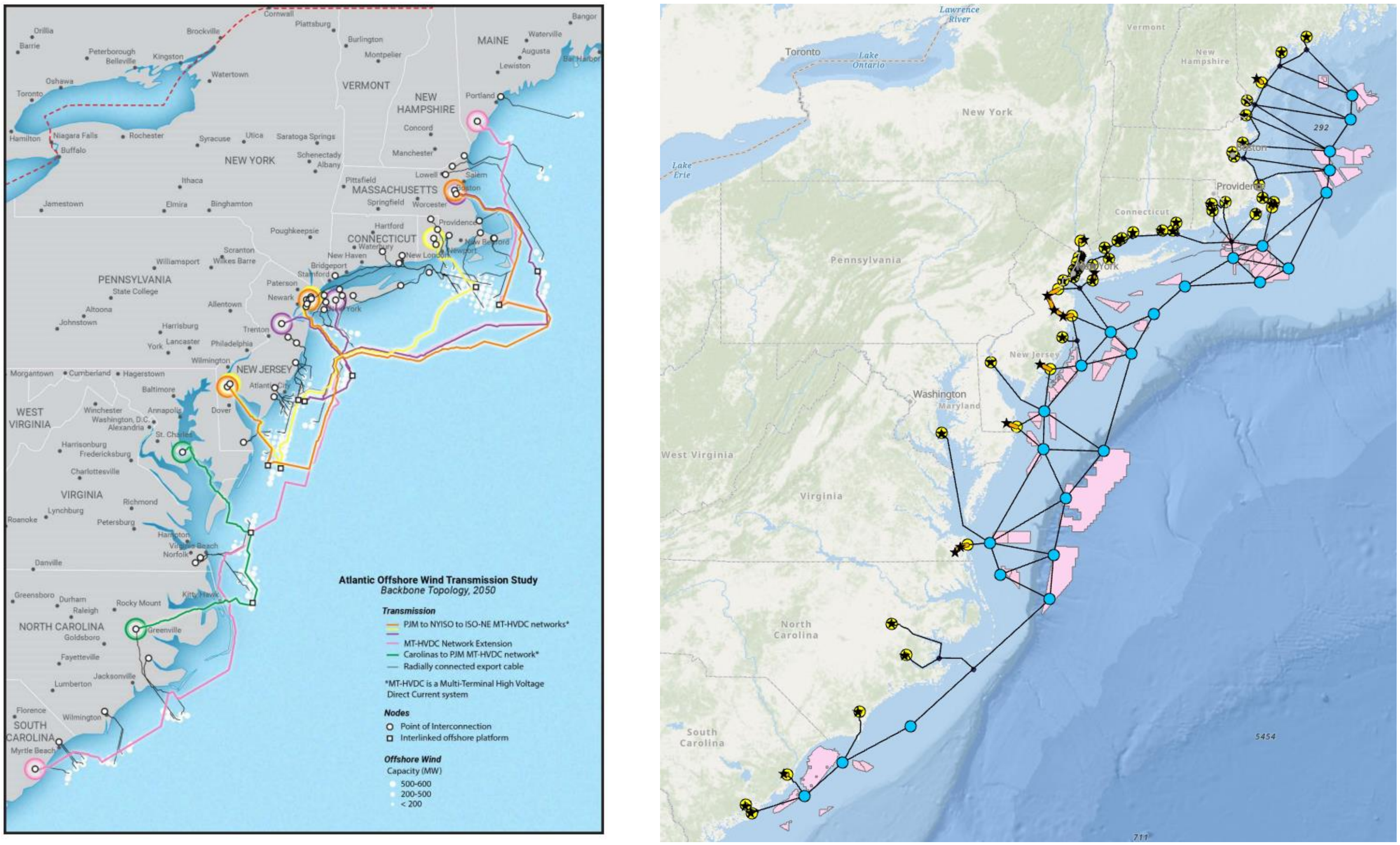

Figure 9b - 15: Hybrid backbone designs, from [119] (left) and from [120] (right)

9b-6 Site assessment plan

The site assessment plan (SAP) is submitted by the offshore wind developer within 12 months of receiving an award to lease an offshore wind energy area. The SAP is required by BOEM and as set forth by Title 30 of the Code of Federal Regulations, §§ 585.605-.618 [121], outlines activities a lessee plans to undertake within their leased area to assess the wind resources and ocean conditions. The SAP describes the surveys and studies the lessee will conduct to evaluate impacts of the proposed offshore wind plant [122]. BOEM reviews the SAP within 90 days of receipt, and if BOEM judges the SAP to be satisfactory, the developers can proceed with site assessment activities.

The purpose of the SAP is to provide a description of site assessment activities to be performed within the lease area. These activities include assessment of the wind resource and meteorological/oceanographic (metocean) conditions, seafloor and other geophysical conditions, and biological impacts.

9a-6.1 Wind resource and metocean assessment

This assessment typically includes installation of a meteorological tower or a meteorological buoy. A meteorological buoy is often preferred because it employs a Floating Light Detection and Ranging (Floating LiDAR) system to collect wind speed data at hub height while also collecting metocean data on wave height, water currents, and sea level changes. This data is used to model wind plants, assess their economic viability, optimize their location, and ensure structural integrity for turbine design. Figure 9b - 16 illustrates a met tower (left [123]) and a met buoy (right [124]).

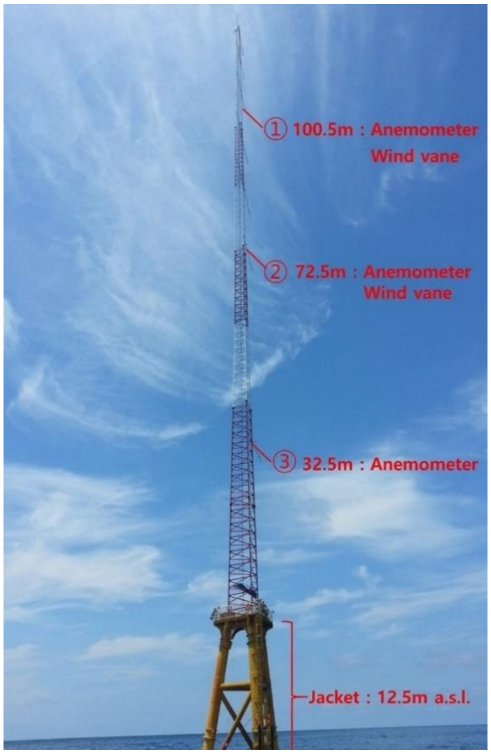

Figure 9b - 16: Met tower (left [123]) and met buoy (right [124])

Data available from a met buoy may include wind speed, air temperature, sea temperature, air-sea temperature, dew point temperature, air-dew point temperature, sea level pressure, water level, peak wind, wind gust, significant wave height, average wave period, and dominant wave period, visibility, and ice conditions. The US National Data Buoy Center (NDBC), within the National Oceanic and Atmospheric Administration (NOAA), provides an interactive website at https://www.ndbc.noaa.gov/ [125] for observing met buoy data from oceans throughout the world. For example, Figure 9b - 17 displays average wind speed (top) and significant wave height (bottom, the average height of the highest one-third of waves) for Station 44025, 30 nautical miles south of Islip, NY on Long Island. The plots give minimum, maximum, average, and ± 1 standard deviation.

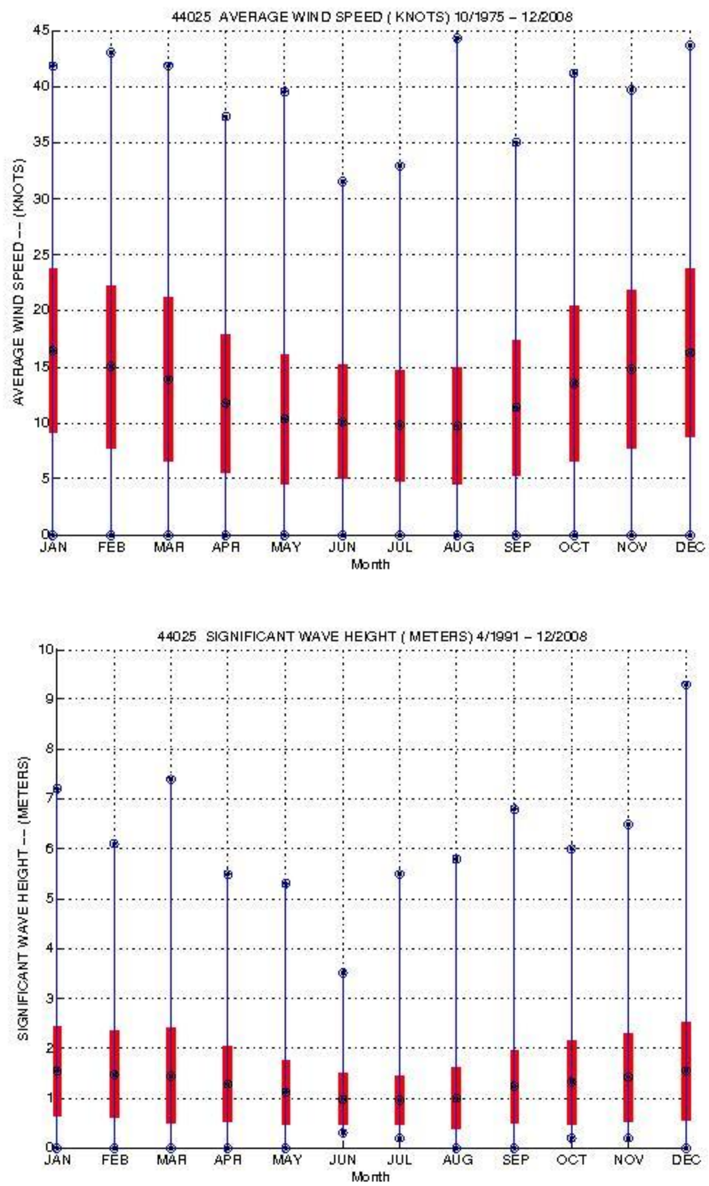

Figure 9b - 17: Average wind speed (top); significant wave height (bottom) [125]

9a-6.2 Seafloor conditions

Seafloor conditions must be evaluated to inform the location and design of foundations and identify shallow hazards including sensitive habitats and archeological resources (shipwrecks and other submerged cultural sites). These efforts also inform cable-routing options**.** Survey vessels typically perform several geophysical and geotechnical surveys. Two common and complementary geophysical surveys are sediment profile imagery (SPI) and multispectral multibeam mapping (MMM). SPI uses photography to create high-resolution images of the top few centimeters of the sediment column, capturing detailed surface sediment characteristics. MMM uses multibeam sonar acoustics (deploying multiple acoustic beams, or pulses of sound) with multispectral imaging to map the seafloor, including bathymetry and sediment types, using backscatter data at multiple frequencies to classify seabed sediments (differentiating between different sediment types, e.g., mud, sand, and gravel) by analyzing the strength and angular dependence of the acoustic signals reflected by the seafloor. These SPI and MMM analyses are then used to assess potential risks, identify suitable locations for wind turbines and cable routes, and ensure environmental compliance. Other geophysical surveys sometimes deployed include seismic surveys (using sound waves to investigate the subsurface geology, providing information about layers beneath the seabed), and magnetometry (to measure the magnetic field of the seabed to identify geological features and potential hazards).

Geotechnical surveys may also be performed, including:

- *Sediment sampling*: collecting sediment samples to analyze their properties, such as grain size, density, and strength, to understand the seabed's stability and its ability to support foundations;
- *Boreholes and vibrocores*: drilling boreholes or using vibrocores (a vibrating device drives a core tube into the sediment) to obtain deeper subsurface samples for geotechnical analysis and testing.
- *Cone penetration testing*: an in-situ ground investigation technique used to assess soil properties and delineate soil layers by pushing a cone with sensors into the ground and recording measurements of tip resistance, sleeve friction, and pore water pressure.

Scour refers to the erosion of the seabed around wind turbine foundations due to the force of currents and waves. Moving water, especially waves and currents, can erode the seabed around structures, leading to scour pits that can undermine foundations and cables. Scour can reduce foundation capacity, affect structural stability, and even cause changes in structural dynamics, impacting energy harvesting. Geophysical surveys, such as seismic surveys or ground-penetrating radar, can be used to identify the subsurface conditions, including the presence and extent of scour holes, and to assess the nature of the underlying soil or rock. However, these methods primarily provide information about the existing scour conditions, while geotechnical analyses determine the potential for future scour and the design of appropriate protection measures.

Scour protection reduces the speed and intensity of currents and waves and thus prevents erosion of the seabed around the foundations and cables of wind turbines. The most common scour protection method for wind turbines is called rock armor, where layers of large rocks are placed on the seabed around foundations. Sometimes a pre-installed filer layer of smaller rocks or materials is placed before the rock armor to prevent the larger rocks from sinking into the seabed and to filter out smaller sediments. Other scour protection methods include geotextiles (fabrics that are used to reinforce the seabed and prevent erosion) and concrete mattresses (precast concrete units deployed on the seabed). A site assessment plan should identify the scour evaluation methods and likely technologies for performing scour protection.

9a-6.3 Biological surveys

A biological survey in an offshore wind site assessment plan typically includes investigations of marine life, benthic and critical habitats, and potential impacts on marine mammals and sea turtles. These surveys may use methods like grab samples, aerial surveys, acoustic monitoring, eDNA sampling, and underwater imagery. Marine life surveys may focus on fish and shellfish (bottom trawling, fish and shellfish surveys, and the use of eDNA sampling to identify and assess fish and invertebrate populations), marine mammals (visual wildlife surveys, passive acoustic monitoring, and Motus tracking to assess the presence and behavior of marine mammals), sea turtle surveys, (typically visual), and birds (bird surveys may be conducted to assess the presence and behavior of birds in the area, including avian habitat mapping). Habitat surveys may use grab sampling, epibenthic beam trawling, and drop-down video (DDV) to assess the composition and health of benthic habitats; they may also focus on identifying and characterizing critical habitats such as eelgrass beds, seagrass meadows, and other important marine ecosystems.

Offshore wind site assessment surveys consider fisheries by incorporating fisheries data and expert input to ensure project development minimizes potential impacts on fish populations and fishing activities. This involves reviewing historical fishing activity, conducting specific fisheries surveys, and integrating results into project planning and environmental impact assessments.

Some met buoys enable collection of wildlife data as well, through sensors that enable the monitoring of bats, birds, fish, and other marine mammals to determine their presence, frequency, and distribution within the lease area [123].

9a-6.4 Illustration of a site assessment plan (SAP)

SAPs become public documents once they are approved. The SAP for Equinor’s 810 MW Wind Plant was submitted June 2018, and amended July 2018, August 2018, and October 2018 [126], and approved in November 2018 [127]. Given that this SAP resulted in an offshore wind project for which construction was initiated, Equinor’s SAP can be considered as an example of one having all the elements of interest to BOEM. Figure 9b - 18 provides the table of contents of this SAP [126].

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Figure 9b - 18: Table of contents for an approved site assessment plan [126]

9b-7 Construction and operation plan

As defined by Title 30 of the Code of Federal Regulations, § 585.620 [128], the construction and operation plan (COP) describes the construction, operations, and conceptual decommissioning plans under the commercial lease, including the project easement. The COP provides the basis for the analysis of the environmental and socioeconomic effects and operational integrity of proposed construction, operation, and decommissioning activities. The COP describes all planned facilities to be constructed, including onshore and support facilities and all anticipated project easements. It must describe all proposed activities, including proposed construction activities, commercial operations, maintenance, and conceptual decommissioning plans, including onshore and support facilities. BOEM must approve the COP before construction can begin. The COP is required by the Code of Federal Regulations, § 585.601.

The offshore wind developer must submit the construction and operation plan (COP) within five years of being awarded the lease.

According to Title 30 of the Code of Federal Regulations, § 585.235 [129], the offshore wind developer must submit the construction and operation plan (COP) during the preliminary period following award of the lease. The preliminary period begins on the effective date of the lease and ends either when a COP is received by BOEM for review or at the expiration of five years, whichever occurs first. It is typical to submit the COP six months before completing the site assessment term outlined in the SAP, but it is possible to submit the COP concurrently with the SAP.

The purpose of the COP is to provide a detailed blueprint to the federal government, specifically BOEM, ensuring that all aspects of the project, from construction to operations and decommissioning, are fully planned and assessed, accounting for environmental and socioeconomic considerations. Title 30 of the Code of Federal Regulations, § 585.626 [130], identifies two sets of information that must be included in a COP, project information and site characterization results.

Project information includes contact information; commercial lease stipulations and compliance; a location plat; structural design, fabrication and installation information; deployment activities (description of safety, prevention, and environmental protection features); a list of solid and liquid wastes generated; a list of chemical products used; description of supporting vessels, vehicles and aircraft; description of operating procedures and systems; decommissioning procedures; list of all necessary Federal, State, and local permitting approvals; proposed measures to minimize environmental impact; evidence of bond coverage to guarantee any remediation needed during construction, operation, or decommissioning; project verification strategy; construction schedule; air quality information; and other information.

There are four types of site characterization results that must be included in a COP [130]. These are:

- *Geological and geotechnical results*: These define the baseline geological conditions of the seabed and provide sufficient data to develop a geologic model, assess geologic hazards, and determine the feasibility of the proposed site.
- *Biological results*: These determine the presence of biological features and marine resources.

- *Archaeological resources/other historic properties*: These provide BOEM with information to conduct the review of the COP under the National Historic Preservation Act (NHPA).
- *Metocean results*: These provide an overall understanding of the meteorological and oceanographic conditions at the site of the proposed facility to identify conditions that may pose a significant risk to the facility.

To complement the above information (obtained from the Code of Federal Regulations), reference [131] is a guideline developed by BOEM that provides an expanded summary of COP requirements.

COPs become public documents once they are approved. The COP for Equinor's 816 MW Wind Plant was submitted November 2023 (five years after approval of the SAP, see Section 9a-6.4) and can be obtained at [132]. The main volume is 1146 pages long, not including its 32 appendices. Given that Equinor's COP resulted in an offshore wind project for which construction was initiated, it can be considered as an example of one having all the elements of interest to BOEM. Figure 9b - 19 and Figure 9b - 20 provides the table of contents of this COP, and Figure 9b - 21 lists its appendices [132]. In addition, the COP included visual simulations of the wind farm as it will be seen from five different nearby beaches; these videos, together with all other COP materials, are publicly available [133].

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Figure 9b - 21: Appendices for an approved construction and operations plan [132]

9b-8 Cost allocation and FERC

The US Federal Energy Regulatory Commission (FERC) has authority over transmission cost allocation. This authority stems from FERC's responsibilities as outlined the Federal Power Act (FPA) [134]. The FPA requires the Federal Government, through the "Federal Power Commission" (changed to FERC in 1977 through the Department of Energy Organization Act [135]), to ensure that rates and conditions for the interstate transmission of electricity are "just and reasonable" and not "unduly discriminatory or preferential." Section 205 of the FPA addresses "Rates and Charges; Schedules; Suspension of New Rates," and outlines the requirement for public utilities to file their rates, terms, and conditions with FERC for approval. Section 206 addresses "Fixing Rates and Charges; Determination of Cost of Production or Transportation," and grants FERC the authority to modify existing rates if they are found to be unjust, unreasonable, or unduly discriminatory.

The reason why FERC regulates cost allocation of electric transmission is that transmission is inherently interstate (with exception of Alaska, Hawaii, and parts of Texas), i.e., it takes place over a network which consists of a configuration of interconnected transmission lines that, as a grid, crosses state lines [136]. This applies to offshore transmission facilities as well, assuming they interconnect to the larger onshore grid. FERC's authority in this way is reinforced by several key rulings, including the 2005 Energy Policy Act (EPACT), the 2011 FERC Order No. 1000, and the 2024 FERC Order 1920.

EPACT [137] encouraged the development of RTOs, which are regional bodies that coordinate transmission planning and operations, giving FERC more authority to oversee the RTO operation, planning, and transmission cost allocation. FERC Order 1000 [138] outlined requirements for transmission planning, including cost allocation methods for new transmission facilities. It established a key principle, that costs be allocated in a manner roughly commensurate with benefits, implying that those receiving no benefit are not required to support those costs.

FERC Order 1920 [139, 140] significantly changed how transmission costs are allocated by requiring long-term, scenario-based regional transmission planning and establishing a process for identifying and selecting cost-effective transmission facilities. Several of its rulings are significant with respect to offshore transmission, as indicated in what follows:

- *Long-term planning*: Order 1920 mandates that transmission providers conduct long-term regional transmission planning, with a minimum horizon of 20 years. Order 1920 also encourages interregional coordination between different RTOs. This emphasis on planning and coordination motivates consideration of meshed and backbone networks for offshore transmission, since, in comparison to lead-line transmission, such networks require longer planning horizons and more substantive design efforts.
- *Benefits consideration*: Transmission providers must consider a broad set of seven benefits when evaluating new facilities. These benefits are (1) avoided or deferred reliability transmission facilities and aging infrastructure replacement; (2) a benefit that can be characterized and measured as either reduced loss of load probability or reduced planning reserve margin; (3) production cost savings; (4) reduced transmission energy losses; (5) reduced congestion due to transmission outages; (6) mitigation of extreme weather events and unexpected system conditions; and (7) capacity cost benefits from reduced peak energy losses. Consideration of these benefits means that offshore transmission projects that can help

integrate offshore wind into the grid are more likely to be considered, especially due to benefits (2), (3), (4), (5), and (7), since offshore transmission facilitates the interconnection of offshore wind resources, as use of those resources usually generate flows in a direction that is counter to the prevailing flows.

- *Cost allocation*: Order 1920 requires transmission providers to file one or more ex ante (before building) cost allocation methods to distribute the costs of selected facilities, providing more certainty that only those who benefit from offshore transmission will need to pay for it.
- *State agreement approach*: FERC Order 1920 expands the role of states in the transmission planning process and allows for cost allocation methods to be determined through state agreements. The New Jersey/PJM State Agreement Approach (SAA) is a prime example of this, where New Jersey and PJM have collaborated on a study agreement to develop a transmission solution for offshore wind, with costs allocated based on a state-specific agreement. As indicated by PJM [141], the SAA "is a provision in PJM's Operating Agreement that enables a state to propose a transmission project for inclusion in PJM's Regional Transmission Expansion Plan that advances that state's Public Policy Requirements, as long as the state agrees to assume the cost of the project's build-out." In 2022, New Jersey utilized this provision to select transmission projects to use PJM's competitive planning process to help New Jersey continue to advance its offshore wind goal of connecting 7,500 MW of offshore wind by 2035 [142]. New Jersey used PJM's SAA a second approach in 2024 [143] when New Jersey asked PJM to solicit transmission solutions to serve an additional 3,500 MW of offshore wind energy by 2040 (together with the 7,500 MW from their 2022 SAA would bring total New Jersey offshore wind to 11,000 MW). Figure 9b - 22 [144] shows future transmission options conceived to support the 2022 SAA proposal.

Figure 9b - 22: Transmission options supporting the 2022 New Jersey/PJM SAA [144]

9b-9 International processes and transmission for offshore wind

In previous sections, this module focused on US processes and transmission for offshore wind. Reference [145] provides data on the number of offshore windfarms internationally, by country, as of April 2025. These data are summarized in Figure 9b - 23. China has led offshore investment with over 41% of the wind farms; the United Kingdom (UK) is a distant second at 15%. However, if all European countries are aggregated, they have over 44% of the wind farms, most of which are in the North Sea [146]. As a result, in this section, we focus on the North Sea area, providing comparative views with respect to processes associated with building (i) offshore wind and (ii) the transmission to support it.

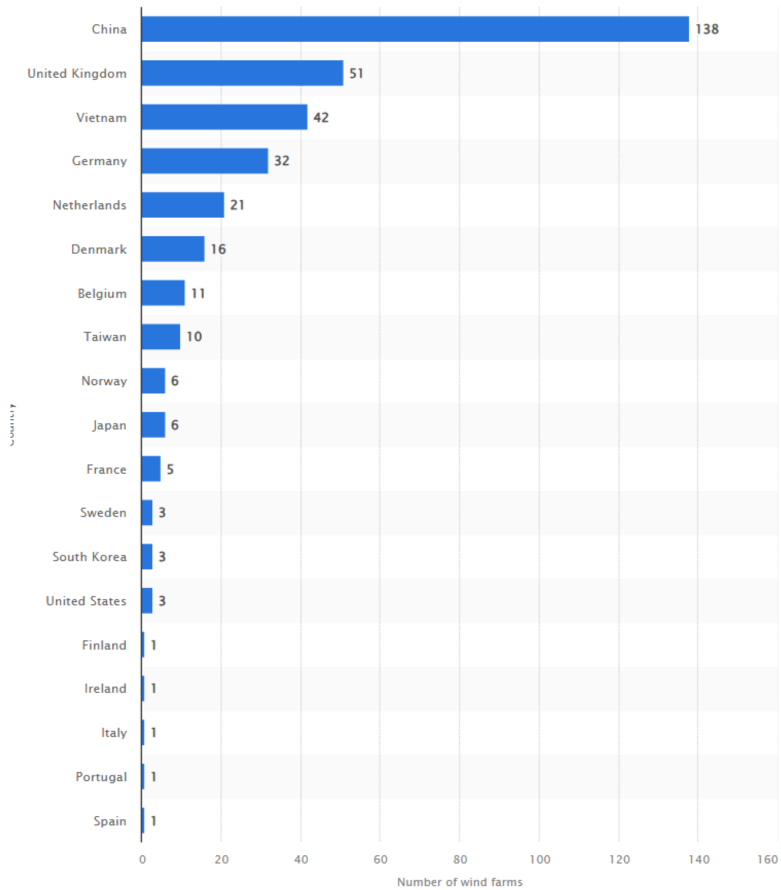

Figure 9b - 23: Number of offshore wind farms by country as of April, 2025 [145]

A forward-looking study on North Sea offshore wind development was performed by the Elia Group and completed in October 2024 [147]. It provided maps like the one shown in Figure 9b - 24 (obtained from [148]) which illustrates offshore wind projects, existing, under construction, and investigated. One observes from this figure that most existing and under construction wind project are off the coasts of England to the west, and Belgium, Netherlands, Germany, and Denmark to the south and east.

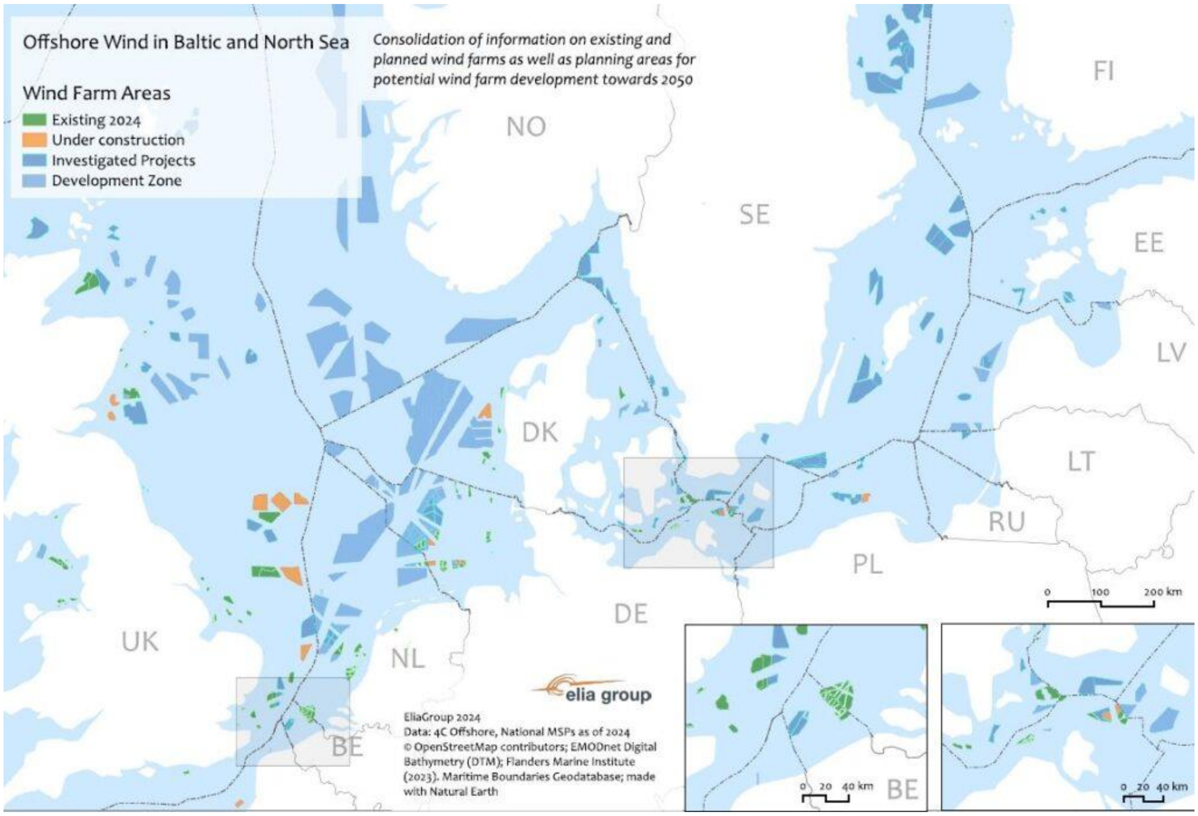

Figure 9b - 24: North Sea offshore wind projects: existing, under construction, investigated [147]

9a-9.1 North Sea offshore wind development processes

North Sea offshore wind development offers a different process dependent on which country's EEZ is targeted. However, as indicated by the global advisory company DHI A/S (specializing in water management and water-related ecosystems) [149], there are five basic phases to a North Sea offshore wind project: (1) Strategic site selection; (2) Planning and development; (3) Installation and construction; (4) Operations and maintenance; (5) Decommissioning. The most significant difference between the way that different North Sea countries address these steps relates to steps (1) and (2), depending on whether these steps are primarily *government-led* or primarily *developer-led*. Indeed, a recent report by the New Zealand Ministry of Business, Innovation and Employment [150] included a characterization of several countries in terms of where they lie on this spectrum. Figure 9b - 25 is taken from Annex 3 [151] of that report.

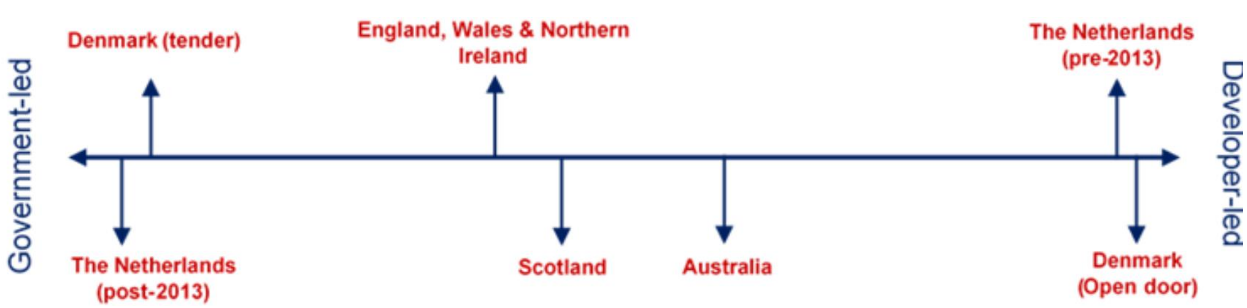

Figure 9b - 25: Offshore wind development processes - government vs developer-led [151]

The Danish Model

The Danish model includes both a government-led "tender" (or bid) process run by the Danish Energy Agency. It had also included a developer-initiated "open-door" policy where developers could propose projects of their own size and location, apply for necessary permits, and ultimately construct and operate the wind farm. However, the open-door policy was suspended in early 2023 due to concerns about compliance with competition rules of the European Union, creating "investment uncertainty" [152] for up to 33 projects totaling about 23 GW of offshore wind in the planning and development phase. In response, a revised "open-door" approach has been proposed that includes a profit-sharing mechanism with the State and will function alongside the public tenders [153].

The Dutch Model

The Dutch model of the Netherlands was highly developer-led before 2013, where project developers were responsible for site selection, investigation, and coordination of the permitting process, all with no guarantee that projects would be approved and therefore high risk [151]. As a result, of 80 initial applications, only four projects were built before 2013, totaling less than 1 GW [154]. Beginning in 2013, the approach has been driven heavily to the government-led side of the spectrum, where it designates exact site locations, conducts site surveys, performs environmental impact assessments, and organizes and conducts the tenders [155], all coordinated by the Netherlands Enterprise Agency, RVO.nl [156].

The UK Model

The UK model varies somewhat between England, Scotland, Northern Ireland, and Wales, but there are many similarities, as a result, here, we focus on the process used by England. The government through the Marine Management Organization (MMO) and The Crown Estate (TCE) operates a 4-stage leasing process that provides the lessor with process and competition information, assesses bidder pre-qualifications, and provides invitation to bid. TCE coordinates the seabed leasing process. Consents (i.e., approvals) are made by the UK Department for Energy Security and Net Zero (DENZ), the Planning Inspectorate (PINS), and the MMO. The National Energy System Operator (NESO), the independent public body responsible for managing and planning the UK's electricity and gas networks, develops, assesses, approves, and coordinates the grid connection.

At the date of this writing, UK has conducted a total of six allocation rounds (AR) of offshore leasing. These rounds, their dates, and their focus areas, are: AR1, 2003-2005, English Channel and North Sea; AR2, 2008-2009, North Sea and English Channel; AR3, 2013, North Sea; AR4, 2021, North Sea; AR5, 2023, Celtic Sea; AR6, North Sea, Celtic Sea, Scottish coast, 2024. These six rounds, including their maximum and awarded strike prices (in 2012 currency), and their capacity awarded, are summarized in Figure 9b - 26 [157] (the dashed boxes serve only as a visual aid in identifying the data relevant for that particular round).

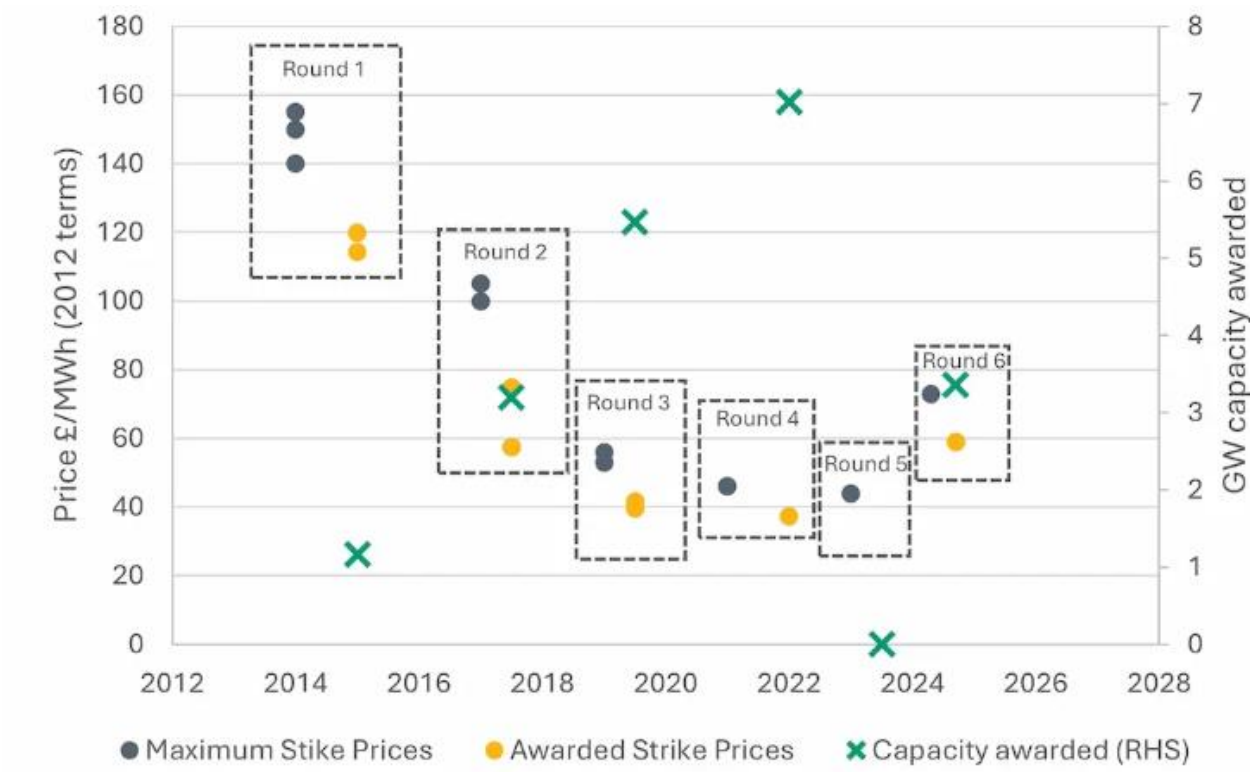

Figure 9b - 26: Summary of UK allocation rounds AR1-AR6

In April 2023, the UK DENZ published a report of work done by its Offshore Wind Acceleration Taskforce (OWAT) [158] describing ways to reduce the offshore wind development timeline from what was then about 10 years to approximately 5-6 years, as summarized in Figure 9b - 27 [158]. Critical to the success of this timeline compression was the implementation of a sophisticated seabed leasing process for AR5, and application of that process for floating offshore wind. The AR5 leasing process is described in an "Information Memorandum" [159] published previous to conducting AR5. Reference to Figure 9b - 26 indicates that there were no awards made for AR5. This outcome resulted from the low Administrative Strike Price (ASP) set by the government. This ASP, set at £44 per MWh, was deemed insufficient to cover rising costs, including inflation, supply chain disruptions, and soaring interest rates. Developers were unable to find a profitable path forward at that price, leading to the lack of bids.

It is interesting to compare the UK allocation round system to BOEM's offshore wind auctions. Whereas BOEM's auctions focus on awarding lease rights to develop wind farms, with bids expressed in units of $/Acre, UK's auctions are on contracts for difference (CfD) on energy, rather than lease rights. The UK CfD bids provide a strike price, capacity, and delivery year. Successful bidders and the government agree to a CfD on energy price (£/MWh) for 15 years which pays the generator the difference between the CfD strike price and the wholesale electricity market price [160]. In this arrangement, the government is represented by the Low Carbon Contracts Company (LCCC), a government-owned private company. The LCCC is responsible for issuing, managing, and making payments. Whereas BOEM's system is designed to provide a fair allocation for offshore wind lease areas, the UK approach is designed to incentivize low-carbon electricity generation and provide long-term price stability to energy producers. The guaranteed strike price of energy provided by the UK system decreases financial risk incurred by developers; as a result, in terms of characterizing these two systems with respect to developer-led vs. government-led, the US system should be positioned to the right of the UK system in Figure 9b - 25.

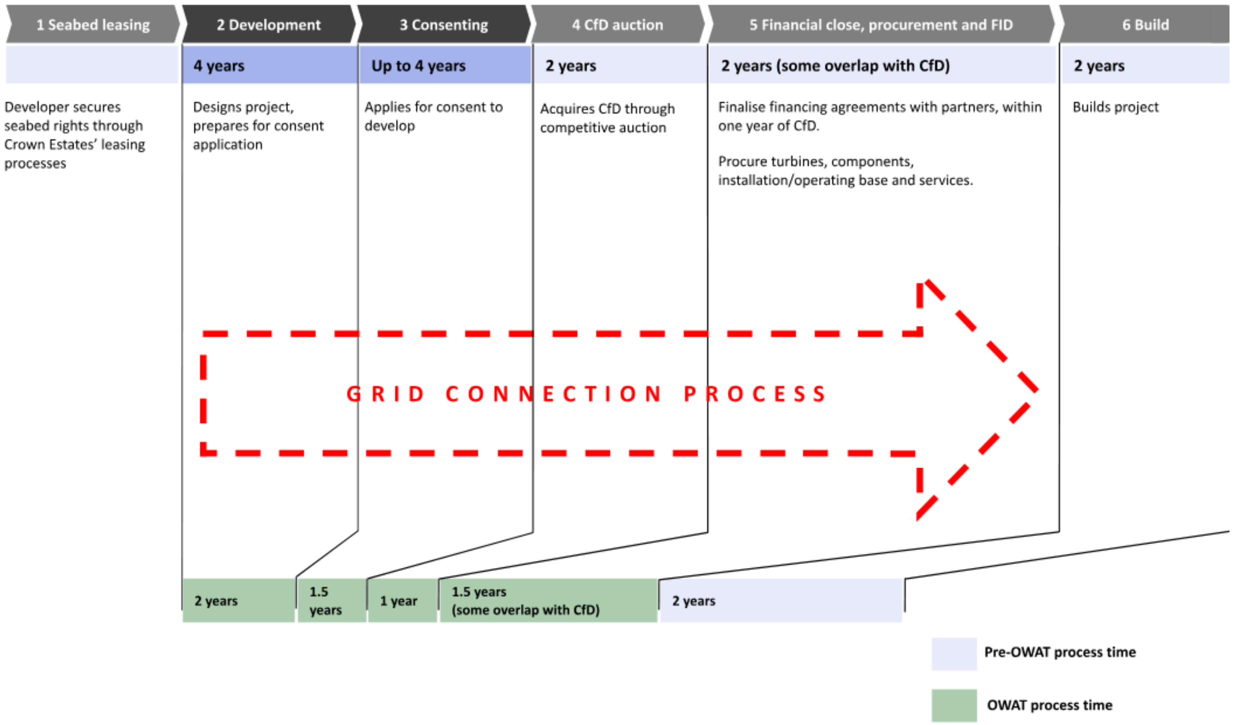

Figure 9b - 27: Timeline reductions for offshore wind energy development process [158]

9a-9.2 North Sea transmission development

The first HVDC line installed in the North Sea was in the HVDC Cross-Channel (IFA) between France and the UK, operational since 1986. In the early years of North Sea offshore wind growth, from 1991-2014, offshore wind plants were located close enough to shore, within about 50 miles, to use AC transmission. However, as offshore wind areas of interest became increasingly distant from shore, developers began considering HVDC. At the same time, the industry, and governments began to identify high value to building transnational interconnectors across the North Sea, not only to connect offshore wind plants to loads but also to support international trading of energy and grid services. The BorWin2 HVDC line, bringing offshore wind to Germany, was commissioned in late 2014, followed by the BorWin3 line in 2018. Since that time, there has been significant North Sea HVDC development, as indicated in Figure 9b - 28 [161], which shows HVDC as dashed lines colored either black (operational), red (under construction), or green (planned). All of these lines use voltage-sourced converters (VSC). Although the source [161] publication date for the figure is recent (2025), it was submitted earlier, and so some updating is necessary. For example, the North Sea Link (UK to Norway) and Viking link (UK to Denmark) are both operational [162, 163, respectively] but are shown as 'under construction' on the map. This map communicates the feasibility of a heavy buildout of undersea HVDC point-to-point transmission. A substantive step not yet taken in the North Sea is to develop undersea HVDC grids. HVDC grids would be necessary to implement the designs illustrated in Figure 9b - 15.

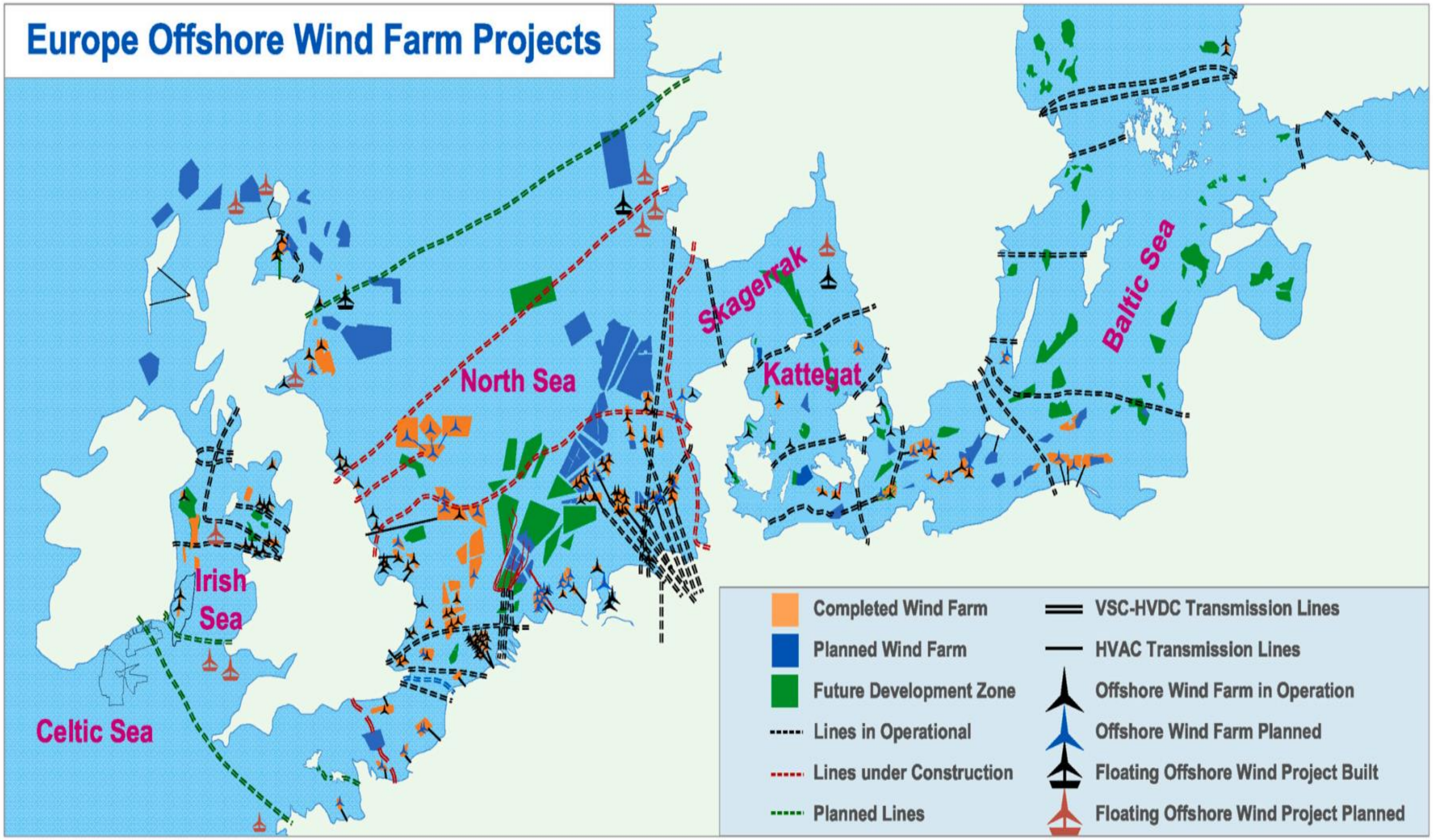

Figure 9b - 28: Wind Farm Projects and Transmission in North, Baltic, Celtic, and Irish Seas [161]

North Sea interconnects are permitted through a combination of national and regional regulations, often involving multiple permissions and approvals. Companies seeking to install these infrastructure projects must navigate a process that includes environmental impact assessments, spatial planning, and often, cross-border collaborations with other North Sea countries. Where cables are laid within a nation's EEZ, that nation's processes and procedures apply. The ability to lay cables in international waters, i.e., outside of any one nation's EEZ, is provided by the United Nations Convention on the Law of the Sea (UNCLOS) which outlines the rights and obligations of states in international waters, including the ability to lay cables for purposes not directly related to the exploitation of resources within an EEZ. There is not a single, centralized international body that directly regulates electric transmission installations in the North Sea outside of EEZs. Instead, UNCLOS sets the general principles, and national legislation and agreements between states bordering the North Sea play a key role in specifics. References [164, 165] provide additional insight into these issues.

9b-10 Main learning points

This module is summarized by the following 15 main learning points:

1. *Ocean jurisdiction*: All coastal nations claim territorial ownership of the 200 nautical-mile exclusive economic zone (EEZ); in the US, the federal government has jurisdiction of all of it with exception of the first three miles which is controlled by the individual state.
2. *US state of offshore wind*: The US offshore wind industry is in its infancy contributing only a tiny fraction of the world's offshore wind capacity. Although the US industry was well-positioned to grow significantly in the next decade, that growth is now slowed or perhaps stopped altogether by a recent executive order by President Trump.
3. *BOEM planning and analysis*: BOEM is responsible to identify suitable areas for wind energy leasing and organize and oversee the environmental compliance reviews and consultations, issue requests for interest, determine competitive interest, issue calls, identify wind energy areas, issue proposed and final notice sales, and design and conduct the lease auctions.
4. *BOEM lease auctions*: Wind lease sales occur through lease auctions organized by BOEM; an ascending clock auction is used where the price increased automatically at regular intervals, and bidders must accept the price or drop out with the last remaining bidder winning the auction. BOEM's auctions allow multi-factor bids, where monetary and non-monetary factors are used to determine the outcome of a lease sale, rather than relying on the highest cash bid.
5. *US offshore transmission authorization*: The US Department of Interior must authorize transmission related to offshore wind either as part of the offshore wind lease or through a right-of-way grant or right-of-use and easement.
6. *US offshore transmission deployment, state role*: States have authority to manage the coastal zones which include islands, transitional and intertidal areas, salt marshes, wetlands, and beaches together with the "state waters" three miles off the coast. They are responsible to permit the transmission landfall, the coastal environmental impact, and any effects on state-owned roads; in addition, they provide the state water easement for underwater cables and are responsible for performing the Federal consistency review. The responsible state agencies for each of these tasks vary from state to state.
7. *Transmission development*: The task of designing the transmission additions necessary to integrate offshore wind to the existing grid lies with the wind plant developer(s) together with the regional transmission operator(s) and transmission owner(s) responsible for the grid to which the offshore wind will be interconnected.

8. *Influence of offshore transmission topology*: When designing for a small number of wind plants, the task of siting, approving, and constructing the transmission to shore should favor the lead-line design, with flexibility to deploy either AC or DC transmission. But when designing for a large number of wind plants, this same task may well favor the backbone design given that it results in fewer connections to shore, but with higher capacity (assuming reliability criteria can be satisfied for loss of one of the landfalls). Backbone designs typically require HVDC transmission.
9. *Site Assessment Plan (SAP)*: The developer prepares the SAP; it provides a description of site assessment activities to be performed within the lease area. These activities include assessment of the wind resource and meteorological/oceanographic (metocean) conditions, seafloor and other geophysical conditions, and biological impacts.
10. *Construction and Operation Plan (COP)*: The COP is provided by the developer and is an extensive document that describes all planned facilities to be constructed, including onshore and support facilities and all anticipated project easements. It must describe all proposed activities, including proposed construction activities, commercial operations, maintenance, and conceptual decommissioning plans, for both offshore and onshore/support facilities.
11. *FERC cost allocation*: FERC has authority to regulate cost allocation of electric transmission, including offshore transmission; an imposed principle is that transmission costs should be allocated according to the benefits received, where FERC has explicitly defined seven distinct benefits that must be considered. Of these seven, offshore transmission projects significantly contribute to five: reduced loss of load probability; production cost savings; reduced transmission losses; reduced congestion due to transmission outages; and capacity cost benefits from reduced peak energy losses, since offshore transmission facilitates the interconnection of offshore wind resources, and use of those resources usually generate flows in a direction that is counter to the prevailing flows.
12. *State Agreement Approach*: FERC Order 1920 expands the role of states in the transmission planning process and allows for cost allocation methods to be determined through state agreements. The New Jersey/PJM State Agreement Approach (SAA) is a prime example of this, where New Jersey and PJM have collaborated on a study agreement to develop a transmission solution for offshore wind, with costs allocated based on a state-specific agreement.
13. *International processes of offshore wind development*: China is leading the world in terms of number of operational offshore wind plants; the US is behind China, four other Asian countries, and seven European countries. The North Sea is a leader on a regional basis.
14. *Government-led vs developer-led*: There has been variation from one country to another and through time on how offshore wind areas are identified and developed, where some countries have implemented highly government-led processes, some have implemented highly developer-led processes, and some have options for both.
15. *North Sea transmission development*: Although early-on, North Sea transmission designs heavily utilized AC lead-line configurations to connect offshore wind plants, there has been a salient change over the last 10 years to build HVDC interconnectors to connect to wind plants and to interconnect the different countries having North Sea coastline. All North Sea HVDC interconnectors have so far been point-to-point; HVDC grids are a direction for future exploration.

Problems and questions

Problem 1: South Carolina has a coastline 187 miles long. (a) How many square miles are in its exclusive economic zone (EEZ)? (b) How many square miles of state waters does it have? (c) How many square miles of federal waters does it have? (d) Given that a wind farm requires 2 acres per 1 MW of offshore wind capacity, compute the upper bound on how much offshore wind capacity could fit into the EEZ of South Carolina. (e) Computer an upper bound on how much offshore wind capacity could fit into the state waters of South Carolina. (f) The actual deployable offshore wind in South Carolina is dramatically less than what your answers indicate. Why?
Note: give answers in square miles and not square nautical miles. 1 nautical mile= 1.15078 miles. 1 mile^2=640 Acres.
Solution:

(a) The EEZ is 200 nautical miles from the normal baseline, and so the EEZ is 200×1.15078=230.156 miles. The area of this region is 230.156×187=<u>43,039.172 miles^2</u>
(b) The state waters are 3 miles from the normal baseline, and so the state waters is 3×1.15078=3.45234 miles. The area of this region is 3.45234×187=<u>645.588 miles^2</u>.
(c) The amount of federal waters is 43,039.172-645.588=42,393.584 miles^2.
(d) 43039.172 miles^2×640 Acres/mile^2×1 MW/2Acres=13,772,535 MW=13.8 GW
(e) 645.588 miles^2×640 Acres/mile^2×1 MW/2Acres=206,588 MW=206.6 GW
(f) There are at least four reasons why the actual deployable offshore wind in South Carolina is dramatically less than these upper bounds we have computed.
    - Some of the EEZ supports other activities, e.g., military, fishing, shipping lanes, and these areas cannot support offshore wind.
    - There are islands off the coast of South Carolina that cannot support offshore wind.
    - The EEZ gets deeper with distance from shore, and at some point, fixed bottom structures are not possible and it is required to shift to floating turbines. Deploying floating turbines will be less economically sound.
    - Proximity to shore may create public resistance due to the impact on visual/aesthetics.

Problem 2: Watch the video <u>link</u> from 5:20-7:20 and identify the reasons why Interior Secretary Burgum gives for de-emphasizing growth in offshore wind as an energy source.
Solution:

- Offshore wind is three times more expensive than onshore;
- It is not viable without tax subsidies yet it needs to stand on its own now;
- NIMBY-ism (not in my back yard);
- Visual impact on views;
- Wildlife concern with whales;
- Opposition groups building against offshore wind;
- Renewables are intermittent and we need baseload;
- We need to power the data center growth to build our AI and win the arms race with China;
- Our electricity must be affordable, reliable, persistent baseload;
- Entire grid is at risk because we have swung too far towards the intermittents.

Problem 3: Assume the players (and their bids) illustrated in Figure 9b - 6 remain the same; the only change is the increment of the announced price, so that instead of three rounds with announced price of $100, $108, and $112, there are 12 rounds with announced prices starting at $100, incrementing by $1 each round, and ending at $112. (a) Provide a table for each round just like the right-hand tables shown in Figure 9b - 6. (b) Should the auction terminate at $111 or at $112. Why?

Solution:

(a)

Announced price: $100

Bidder	Bid	Exit Bid
Bidder A	In	
Bidder B	In	
Bidder C	In	

Announced price: $101

Bidder	Bid	Exit Bid
Bidder A	In	
Bidder B	In	
Bidder C	In	

Announced price: $102

Bidder	Bid	Exit Bid
Bidder A	In	
Bidder B	In	
Bidder C	In	

Announced price: $103

Bidder	Bid	Exit Bid
Bidder A	In	
Bidder B	In	
Bidder C	In	

Announced price: $104

Bidder	Bid	Exit Bid
Bidder A	In	
Bidder B	In	
Bidder C	In	

Announced price: $105

Bidder	Bid	Exit Bid
Bidder A	In	
Bidder B	In	
Bidder C	In	

Announced price: $106

Bidder	Bid	Exit Bid
Bidder A	Out	$105
Bidder B	In	
Bidder C	In	

Announced price: $107

Bidder	Bid	Exit Bid
Bidder B	In	
Bidder C	In	

Announced price: $108

Bidder	Bid	Exit Bid
Bidder B	In	
Bidder C	In	

Announced price: $109

Bidder	Bid	Exit Bid
Bidder B	In	
Bidder C	In	

Announced price: $110

Bidder	Bid	Exit Bid
Bidder B	In	
Bidder C	In	

Announced price: $111

Bidder	Bid	Exit Bid
Bidder B	Out	$110
Bidder C	In	

Announced price: $112

Bidder	Bid	Exit Bid
Bidder C	Out	$111

(b) The answer to this question is a function of "auction rules." The rule "The auction terminates when there is only one remaining bidder" would have the auction terminating at an announced price of $111; this rule is beneficial to the bidder. The rule "The auction terminates when the announced price is greater than the highest bid price" would have the auction terminating at an announced price of $112; this rule is beneficial to the auction (seller).

Problem 4: Regarding Table 9b - 1, (a) list the different activities performed at the state level (first five rows) for permitting/reviewing some feature of offshore wind; (b) the "Permit for transmission system connecting offshore wind to electricity grid" is usually done by the State Utilities Commission (also known as a Public Utilities Board, Public Utilities Commission, or State Corporation Commission), but there are exceptions. What is a state utilities commission? (c) Identify the states that are exceptions based on the entity's name given in the table states that use another agency for permitting, and check the references provided to verify that these entities are indeed exceptions. (d) Why do you think these states have decided to give this authority to another agency besides the state utilities commission?

Solution:

(a) Permit for transmission system connecting offshore wind to electricity grid; Permits for coastal environmental impacts; Easement for underwater cables; Federal Consistency Review; Permit for work on state-owned roads. (b) A state utilities commission is a state agency responsible for regulating utilities like electricity, natural gas, water, and telecommunications. It is the responsibility of these commissions to ensure that utilities provide reasonable, safe, reliable, and efficient services to customers at just and reasonable prices. Usually, they are comprised of 3-5 commissioners appointed by the governor, and they serve for 3-6 years. The National Association of Regulatory Utility Commissioners (NARUC) is an independent organization representing all of the state utility commissions in the US – see https://www.naruc.org/. (c) The states having another entity responsible for issuing the "permit for transmission system connecting offshore wind to electricity grid" are Massachusetts, Rhode Island, Connecticut, and North Carolina. (d) The perspective is that offshore transmission connections are unique and require a level of knowledge and expertise that is outside the scope of the utilities commission. For example, in Massachusetts, the Massachusetts Department of Energy Resources (DER), not the Public Utilities Commission (PUC), is responsible for offshore wind transmission facilities permitting. The DER has a statutory mandate to approve the construction and operation of such facilities, while the PUC oversees the electric utilities themselves. The DER's approval process involves a detailed review of the project's environmental impact and cost, including consideration of transmission line routes and their potential effects on ecologically sensitive areas.

Problem 5: Section 9a-5.3.1 states that "because the backbone transmission is typically of significant length, line charging inhibits use of an AC transmission solution, and so backbone designs are typically DC." (a) What is "line charging"? (b) Why does "line charging occur with AC but not DC? (c) Why is "line charging" a problem for long AC lines but not for short ones?

Solution:

(a) Line charging is the tendency of an AC transmission line to generate leading (capacitive) reactive power, resulting in higher currents for the same amount of real power transfer; (b) Line charging occurs with AC but not DC because capacitance only has influence under a changing (alternating) voltage (for DC, capacitance looks like an open circuit); (c) Line charging is a problem for long AC lines because the capacitance of the line is directly proportional to its length.

Problem 6: The footnote 2 in Section 9a-5.3.2 indicates that remedial action schemes (RAS) can address the reliability problem associated with high-capacity landfalls, where the landfall capacity exceeds the single source contingency limitation (SSCL) of the region. Describe how this might work. Note: (i) Another term used for RAS is special protection scheme (SPS). (ii) A good resource describing SPS is located at https://pserc.wisc.edu/wp-content/uploads/sites/755/2018/08/S-35_Final-Report_Dec-2010.pdf.

Solution: If a high capacity landfall connection is lost (outaged), then the normal flow through that connection would need to transfer to other connections to shore, and assuming those other connections already carried flow, they would be overloaded, resulting in problems on the offshore side and onshore side in terms of exceeding emergency circuit loading limits, voltage depression (and possible voltage instability on the AC side) and/or transient instability on the AC side. Application of a RAS would do two things: (i) reduce (or trip) generation on the offshore side; and (ii) interrupt load on the AC side. These two things would serve to reduce the described negative impacts of the increased injections in the parallel connections to shore.

Problem 7: Section 9b-8 describes a "state allocation approach" (SAA). This approach to cost allocation has been very useful and promising. Why?

Solution: A state allocation approach to offshore wind growth is of high interest because it allows individual states to tailor their approach to local needs and resources while also fostering regional supply chain development and investment. This approach also helps build support for offshore wind within coastal communities and ensures that jobs and economic benefits are distributed locally.

Problem 8: Referring to Figure 9b - 25, the text reads, "in terms of characterizing these two systems with respect to developer-led vs. government-led, the US system should be positioned to the right of the UK system." What does this mean? And why is this?

Solution: This means that the US system is more "developer-led" than the UK system, or said another way, the UK system is more "government-led" than the US system. The reason for this is that the nature of the UK auction system guarantees developers an energy price; the US system offers no such guarantee. Thus, in the US, developers incur more risk and therefore have been given more autonomy for design and operation than their counterparts in the UK.

Problem 9: Figure 9b - 15 illustrates two different hybrid transmission designs for the US Atlantic Coast. (a) What is "hybrid" about these designs? (b) Do you see significant similarities between these two designs? (c) Do you see significant differences between these two designs?

Solution: (a) These designs are hybrid because they utilize a topology that includes both backbone transmission as well as lead-line transmission; (b) As similarities, both designs span approximately the same geographical distance, from Maine to South Carolina; in addition, both designs have a concentration of connections at load centers. (c) As differences, the right-hand design has more loops than the left-hand design. In addition, in the left-hand design, some windfarms are connected to land using AC transmission in the lead-line topology; the right-hand design is completely HVDC and does not use lead-line topologies.

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