

Transmission Expansion Planning for Offshore Wind on the U.S. Atlantic Coast:  
A Comparative Analysis

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## Abstract

Offshore wind on the U.S. East Coast is a key renewable resource for decarbonizing our electric grid. States have committed to deploy 80 gigawatts of offshore wind by 2050. The long-term transmission design to access this resource in a coordinated manner can create a system that delivers clean energy, enables benefits from increased interregional transfer capacity, and minimizes total investment costs. However, there is little to no precedent for transmission planning between multiple regions to facilitate these benefits. This comparative analysis focuses on the difference in frameworks of two recent publications that transcend typical regional siloes by modeling transmission expansion for 85 gigawatts or more across the East Coast. Establishing a comparison of the strengths, limitations, and results of each study provides decision-makers and stakeholders with a way to understand the implications for long-term planning.

## Acknowledgements

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## List of Acronyms

<b>AC</b>	alternating current
<b>AOSWTS</b>	Atlantic offshore wind transmission study
<b>BCR</b>	Benefit-cost-ratio
<b>CEP</b>	Coordinated expansion planner
<b>DC</b>	direct current
<b>DOE</b>	Department of Energy
<b>GW</b>	gigawatt
<b>HVAC</b>	high-voltage alternating current
<b>HVDC</b>	high-voltage direct current
<b>ISO</b>	Independent System Operator
<b>ISO-NE</b>	Independent System Operator New England
<b>kV</b>	kilovolt
<b>MMWG</b>	Multiregional Modeling Working Group
<b>MW</b>	megawatt
<b>MWh</b>	megawatt hour
<b>NYISO</b>	New York Independent System Operator
<b>OSGT</b>	offshore grid template
<b>OSPREE</b>	Offshore Power Research and Education
<b>OSW</b>	offshore wind
<b>PCM</b>	production cost model
<b>PJM</b>	PJM transmission planner
<b>POI</b>	point of interconnection
<b>ReEDS</b>	Regional energy deployment system model
<b>RTO</b>	Regional Transmission Operator
<b>SSCL</b>	single source contingency limit
<b>TEP</b>	Transmission expansion planner

## Chapter 1: Introduction

States on the U.S. East Coast (also referred to as the Atlantic Coast) have set individual targets that together exceed 80 gigawatts (GW) of offshore wind deployment by 2050, with more than 60 GW of projects already in various stages of development (McCoy et al., 2024). Offshore wind (OSW) is a relatively nascent industry in the United States, with the first utility-scale offshore wind farm, South Fork Wind, commissioned in 2024 and serving New York (DiGangi, 2024). As a result, the process for interconnecting OSW to the power grid is an evolving sub-field of transmission planning. Transmission planning is mostly led by regional planning entities and has historically not focused on interregional transmission due to challenges in coordinating across grid regions and operators. Proactive planning for offshore wind transmission on the East Coast, which spans multiple planning regions, can increase grid reliability and create multiple benefits across regions.

While there has been state and regional action towards proactive and interregional transmission development to ensure timely access to offshore wind power, there is a gap in multi-region studies that analyze paths for the development of offshore transmission more broadly across the East Coast (Bothwell et al., 2021). The recent publication of two first of a kind studies produced two sets of results for Atlantic Coast offshore wind transmission expansion pathways, including topologies (how transmission lines are connected), costs and benefits, points of interconnection (POIs), and grid infrastructure investments. The side-by-side comparison of these studies introduces multiple ways to think about transmission expansion for offshore wind. The first study, *The Atlantic Offshore Wind Transmission Study* (AOSWTS) (2024), was conducted by a United States Department of Energy (DOE) team led by researchers at the Pacific Northwest National Laboratory and the National Renewable Energy Laboratory

(NREL) (Brinkman et al., 2024). The second study, *Offshore Wind Transmission Expansion Planning for the U.S. Atlantic Coast (2025)*, was conducted by a multi-university research team of Tufts University, Iowa State University, and Clemson University (Hines et al., 2025) This study is published through Tufts University’s Offshore Power Research and Education (OSPRES) report series and will be referenced as the OSPRES study. The OSPRES team used power flow models, including a transmission expansion planning model and a coordinated expansion planning optimizer, developed by researchers at Iowa State University, to select transmission investments and topologies that accommodate a given level of offshore wind deployment while minimizing the total net present value costs of investment and operation (Hines et al., 2025). In parallel, the DOE study team used a capacity expansion optimization model that aimed to minimize capital and operational costs while incorporating market and policy considerations offshore space use constraints, and technology development timelines (Brinkman et al., 2024). As a result, the two studies have created deployment paths and topologies for offshore wind transmission that reflect each modeling framework.

In June of 2023, the OSPRES study research team hosted a workshop titled “No Transition Without Transmission,” highlighting the crucial role that transmission plays in the energy transition from fossil fuels to renewable sources like offshore wind (Harris et al, 2023). The workshop was structured around presenting initial study findings for 76 GW of offshore wind and creating a participatory conversation across the technology-policy interface of electricity transmission development. To this end, presenters covered in-depth power-flow modeling study results, technical needs and standards for offshore transmission, policy and regulatory considerations, and represented the perspectives of government, industry, and academia. Attendees represented a similarly diverse range of stakeholders and participated in informal

discussions under Chatham House Rules about choosing points of interconnection, transmission siting and permitting, the role of state and federal government, and more. Conducting the workshop in this way allowed for transparent exchange of ideas and recommendations outside of traditional formal processes in transmission planning. Hines et al. (2025) envision a similar ongoing process between transmission planners and decision-makers about power-systems decisions, using the tools and models developed to enable rapid assessments of transmission options by a broad set of stakeholders in a process called responsive analysis:

*“Responsive analysis is a method to bring stakeholders into the process of design and development of Atlantic Coast OSW and the transmission system it requires. This is important because insights that emerge from the complex engineering design effort behind offshore transmission directly affect the social, political, and environmental (SPE) impacts of such a system. Conversely, SPE considerations must inform the framing and evaluation of such engineering efforts.”* pg. 68

This comparative analysis aims to contribute to this ongoing effort of cross-sectoral engagement and participation by establishing a common understanding of these parallel but independent studies and their transmission planning implications. The two papers represent distinct sets of tools and models that develop transmission expansion results for coordinated deployment of OSW transmission. Each focus on transmission that leverages interregional transmission to decarbonize the grid and increase grid reliability while minimizing costs, providing net benefits, and maximizing the efficient and environmentally conscious use of space.

Chapter 2 positions these novel studies in the landscape of transmission planning, interregional transmission planning, and offshore transmission planning to date. Chapter 3 outlines the comparison methods and analytic framework. Chapter 4 outlines the results of the

comparative analysis, focusing on identifying common recommendations, key differences in assumptions and approaches, and opportunities for integration into future planning and decision-making. Chapter 5 discusses key findings, takeaways, limitations, and opportunities for future work.

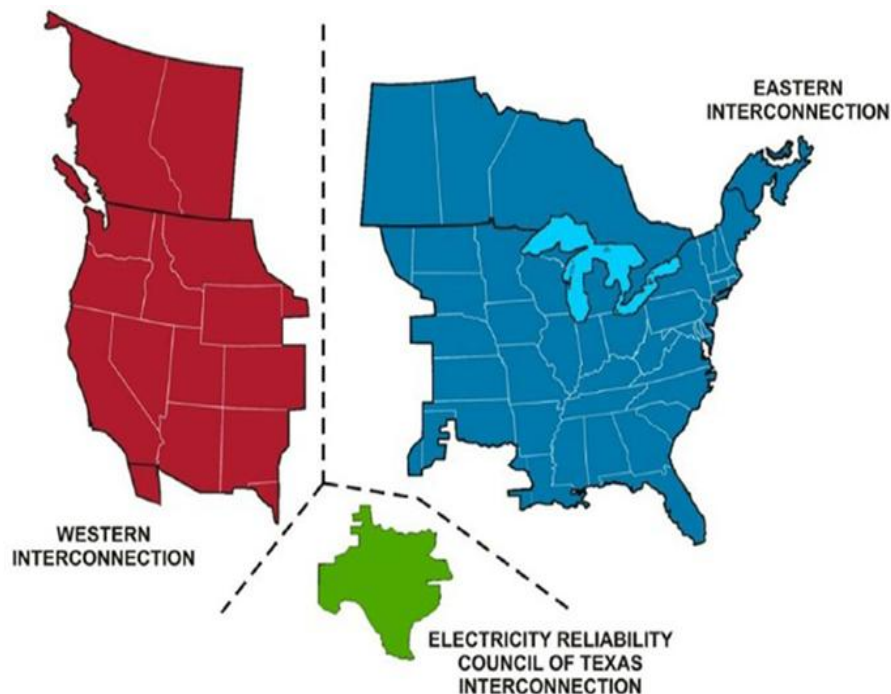
*A note about the current federal landscape*

In January 2025, the current administration issued executive action that withdrew areas on the outer continental shelf from OSW leasing and mandated review of current OSW siting and permitting practices (The White House, 2025). This analysis does not incorporate the impacts of this action at the federal, state, or project level or other changes that create uncertainty in the industry. Regardless of these recent federal actions, coordinated planning efforts for an interregional power system that incorporates offshore wind are essential to achieving power systems decarbonization.

## Chapter 2: Literature Review

The U.S. electric grid is an expansive system that transfers electricity from generation sources to load centers, sometimes transporting power hundreds of miles from generation to load. This requires long-distance infrastructure to transport power efficiently, reliably, and safely. These long-distance lines comprise the transmission system, traversing hundreds of miles of land and subject to regulation and oversight in multiple jurisdictions at the local, state, regional, and federal levels. Today, the U.S. electric grid is divided into three networks, the Eastern Interconnection, the Western Interconnection, and the Texas Interconnection, as shown in Figure 1, which operate primarily independently of each other with some limited electric transfer capacity (M. H. Brown & Sedano, 2004). Regional balancing authorities, including regional transmission operators (known as RTOs) and independent system operators (known as ISOs) oversee grid operations within these areas by balancing supply and demand and conducting

**Figure 1.** The three interconnections of the U.S. grid



*Note.* From Federal Energy Regulatory Commission (FERC, 2025, FERC Western Energy Markets Explainer (<https://www.ferc.gov/OPP/western-markets-explainer>)). In the public domain.

transmission planning that ensures grid function and reliability and sufficient generation to meet load requirements.

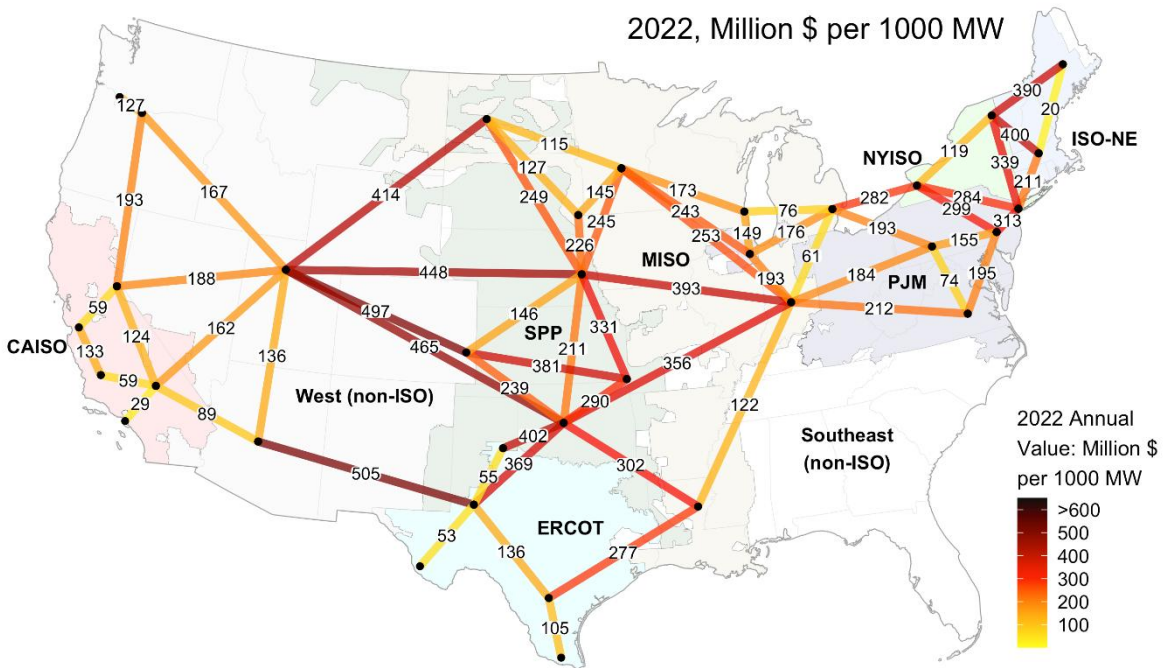
## 2.1 Interregional Transmission

By design, transmission planning is regionally focused and conducted within the jurisdictional footprints of each transmission planner. As a result, planning has not focused on interregional transmission connecting two or more balancing authorities, because of challenges with coordinating across grid regions and operators. While there are some existing interregional connections, they are limited in capacity and often used inefficiently (Simeone & Rose, 2024). Barriers include a lack of process for conducting interregional planning, inconsistent benefits calculations and cost allocation methods across regions, complex siting and permitting, and varying methods for determining interregional transmission needs (Homer et al., 2025). Notwithstanding the established planning norms of our current system, the broad consensus across recent studies is that an increase in transfer capability from interregional transmission can yield multiple benefits, including increasing grid reliability, mitigating grid congestion, reducing renewable energy curtailment, and associated economic benefits (P. R. Brown & Botterud, 2021; Homer et al., 2025; Millstein et al., 2022; Pfeifenberger et al., n.d.; Prada & Ilic, 2015; Simeone & Rose, 2024).

A number of recent studies conducted by federal, state, and industry entities have outlined the need for interregional transmission to maintain grid reliability and function, in particular the DOE's National Transmission Needs Study (Needs Study) which found that there is a national need for a 57% increase in transmission by 2035 to accomplish grid decarbonization goals (DNV-GL, 2020; Schulte & Wahle, 2024; United States Department of Energy, 2023). Figure 2

shows the marginal value of interregional transmission in relieving congestion, showing significant interregional economic benefits to reducing congestion (Millstein et al., 2022). Additionally, a key benefit of interregional transmission is an increase in operational grid flexibility that supports reliability. Interregional transmission increases reliability by enabling shared generation capacity across regions that are experiencing varying conditions, including weather events, generator or line outages, and time-differentiated supply and demand peaks (P. R. Brown & Botterud, 2021; Simeone & Rose, 2024; United States Department of Energy, 2023, 2024).

**Figure 2.** Marginal value of transmission in relieving congestion in 2022 in million \$/1000 MWh.



*Note.* From Empirical Estimates of Transmission Value using Locational Marginal Prices. Millstein et al, 2023, United States Department of Energy, p15 ([https://eta-publications.lbl.gov/sites/default/files/lbnl-empirical\\_transmission\\_value\\_study-august\\_2022.pdf](https://eta-publications.lbl.gov/sites/default/files/lbnl-empirical_transmission_value_study-august_2022.pdf)).

There are documented cases of the benefits for interregional transmission, including recent extreme weather events. In February 2021, Winter Storm Uri in Texas caused cascading failures

in the natural gas and electricity systems and 10 million people to lose power, with spikes in wholesale electricity from \$30/Megawatt hour (MWh) to \$9,000/MWh and more than \$90 billion in estimated economic losses (Busby et al., 2021; Potts et al., 2024). Texas operates on a separate interconnection from the much larger Eastern and Western Interconnections in the U.S with less than 2,000 megawatts (MW) of transfer capacity with other regions (which only accounted for around 2% of the peak demand during the storm) (Busby et al., 2021). While the multi-day outages were a result of a combination of factors including failure to weatherize critical infrastructure, an increase in transfer capacity between the Texas grid and other regions could have helped mitigate some of the worst impacts (Botterud et al., 2024; Busby et al., 2021; Levin et al., 2022).

During the unanticipated extensive coal and gas plant outages caused by extreme cold in the 2022 Winter Storm Elliot in the East, existing interregional transmission allowed the regional transmission operator for the mid-coast, PJM, to avoid widespread blackouts experienced by the Southeast region.<sup>1</sup> However, studies found that increased interregional transmission between the Southwest Power Pool regional transmission operator, PJM, and the Southeast could have both reduced Southeast blackouts and generated up to \$100 million in economic benefits (Goggin & Zimmerman, 2023; PJM, 2023; Slanger, 2023). During the storm, there was a time when the Southwest Power Pool was curtailing 3 GW of wind power that could have alleviated simultaneous widespread blackouts in the Tennessee Valley Authority utility area with additional interregional transmission capacity (Slanger, 2023). These events and the broader recognition of interregional transmission benefits have led to consideration of establishing minimum

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<sup>1</sup> PJM is a transmission planning operator that was previously named the Pennsylvania-New Jersey-Maryland power pool for its original service area. With an expanded service area which includes multiple other states, the RTO is now referred to as PJM.

interregional transfer capability requirements that mandate a set amount of capacity able to be shared between regions (Goggin et al., 2023; Homer et al., 2025).

## 2.2 Interregional Transmission and Offshore Wind

On the East Coast, planned and proactive offshore transmission could not only efficiently interconnect planned OSW power and create economic transmission investments, but also create interregional pathways that address on-shore grid concerns of reliability, congestion, and affordable energy (Millstein et al., 2022; Newell et al., 2021; Pfeifenberger et al., 2020, 2023; Tandon Manz et al., 2022). Pfeifenberger et al. (2023) found in a survey of existing studies that proactive planning for OSW could result in a 50% reduction in marine cable installations and up to 70% fewer onshore transmission investment upgrades. A number of existing state efforts to expand coordinated transmission for offshore wind (and more broadly) recognize benefits of and possibilities for planned OSW and transmission within the East Coast planning regions, including ISO New England (ISO-NE), New York ISO (NYISO), PJM, and the Southeast (Pfeifenberger et al., 2021, 2023; Shields et al., 2022).

New York has started planning for OSW technology standards that enable interlinked offshore connections, PJM has begun integrating OSW public policy needs with transmission expansion through the State Agreement Approach (which allows a state to propose a transmission project that advances the states public policy goals in offshore wind for inclusion in the Regional Transmission Expansion Plan), and states in the Northeast have begun collaborating on OSW procurements, supply chains, and transmission (Gnanarathna et al., 2023; MA DOER et al., 2023). The Northeast States Collaborative on Interregional Transmission (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Jersey, New York, Rhode Island, and Vermont)

formed in 2024 in a first of its kind effort to identify shared interregional transmission priorities in collaboration with federal authorities (Silverman & Glatz, n.d.). The group specifically outlined intentions to advance interregional transmission for offshore wind through a strategic action plan and coordination on technical standards for offshore wind transmission equipment that ensure interoperability across regions.

These actions are indicative of growing momentum toward coordinated planning, but also recognize the technical, regulatory, and policy challenges that states and planners are facing, such as cable and converter technology choices, economic valuation and configuration of offshore transmission, siting and space use constraints, and cross boundary regional coordination processes (Homer et al., 2025; Simeone & Rose, 2024). Recent studies and action plans call for key actions to overcome these barriers including creating and enabling multi-state and region decision-making bodies, and increasing collaboration and communication between states, regional transmission planners and operators, state decision-makers, and other stakeholders (Baker et al., 2024; Homer et al., 2025; Pfeifenberger et al., 2023).

A US Department of Energy literature review of East Coast offshore transmission studies for offshore wind found that studies were isolated to individual regions, lacked clear analysis of routing and points of interconnection (POIs), lacked coordination between generation and transmission investments, and didn't incorporate resilience and reliability (Bothwell et al., 2021). The publication of the Atlantic Offshore Wind Transmission Study and the Offshore Transmission Expansion Planning for the U.S. Atlantic Coast reports begin to fill this gap. Each recognizes the potential benefits of interregional wind transmission for optimized offshore wind integration on the East Coast and models the integration of 85 or more GW of offshore

wind between ISO-NE, NYISO, PJM, and the Southeast with 20 year planning horizons (Brinkman et al., 2024; Hines et al., 2025). While there are studies preceding these for state or regional OSW transmission, these studies grow the basis for planning discussions and actions for a coordinated grid. There are not yet comparisons of the methods or outcomes for these, this analysis will fill this gap and establish the strengths, limitations, and complementary aspects of each.

## Chapter 3: Methods

This study uses a qualitative, document-based comparative analysis to examine two novel studies of offshore wind transmission planning along the U.S. Atlantic Coast: the U.S. Department of Energy’s Atlantic Offshore Wind Transmission Study (2024) (DOE study) and the Offshore Wind Transmission Expansion Planning for the U.S. Atlantic Coast report (2025) (OSPRES study) (Brinkman et al., 2024; Hines et al., 2025). The primary aim is not only to identify points of similarity and divergence, but to understand how these studies can jointly inform future regional and interregional transmission planning efforts by policymakers, grid operators, and other decision-makers. Each study has supplemental documents that were considered as part of the background and analysis. These documents include a DOE literature review precursor to the transmission study, the *Atlantic Offshore Wind Transmission Literature Review and Gaps Analysis*, and the documentation for the 2023 East Coast Offshore Transmission Workshop held by the OSPRES research team in June 2023 for presentation of preliminary results ( the *Rapporteurs Report to the June 22, 2023 Transmission Workshop* which is part of the Tufts Offshore Power Research and Education report series) (Bothwell et al., 2021; Harris et al., 2023).

### Study Selection and Rationale

The two studies were selected for their timing, influence, and complementary perspectives. The DOE study represents a comprehensive federal modeling initiative with broad regional scope and a focus on interconnection options and transmission configurations for large-scale offshore wind. The OSPRES study, in contrast, offers a power-systems based modeling approach with an emphasis on scalability, power flow optimizations, and national scale implications. Together, these studies reflect two leading yet distinct approaches to offshore wind

transmission planning. Analyzing how these frameworks align can help identify actionable insights and inform conversations among stakeholders in the current planning landscape.

### Analytical Framework

The analysis proceeded in two phases:

- Phase 1: Each study was analyzed independently to understand its structure, assumptions, and conclusions.
- Phase 2: A cross-study comparison was conducted, focusing on the analytical themes. Key findings were compared based on convergence and divergence.

In Phase 2, a thematic comparative framework was developed to guide the analysis, focusing on areas of the studies that could be compared and are centered in the regional conversations about offshore transmission. Both documents were reviewed in full, and key sections were analyzed using the following themes:

1. Planning Scope and Objectives
  1. Geographic region considered: The geographic region for each study including RTO/ISO footprint and states.
  2. Offshore wind lease areas considered: The extent and anticipated power production of each Bureau of Ocean Energy Management (BOEM) wind lease area (already bid or planned)
  3. Modeling timeframe: The anticipated timeline for injection of OSW into the electric grid and planning horizon for each model.
2. Modeling process and sequencing
  1. Baseline transmission topology

The assumption of the baseline topology is a key difference that ultimately impacts how many points of interconnection there are, where offshore connections are made, and how much power is carried by each line.

## 2. Transmission expansion steps

Each model has a separate process for how new generation and transmission are chosen. Comparison of the way these are modeled highlight the economic and grid planning impact for new generation and transmission.

## 3. Power flow Modeling

1. Each studies approach to power flow will be compared based on use of representative or modeled power flows, granularity of model of electric grid, role in grid modeling

## 4. Technology

1. Choice of transmission line type

Line type affects both the topology configuration, infrastructure needed (such as converters), and capacity of lines and POIs. The comparison will outline the technology type assumed by each model for offshore (and onshore where relevant) interregional cables, cables connecting to shore, and onshore transmission upgrades (for example High voltage alternating current (HVAC) vs high voltage direct current (HVDC))

## 5. Cost Modeling

1. Transmission cost considerations

Each model considers cost differently, using methods such as production cost modeling, cost of transmission infrastructure upgrades, market optimization, or a

combination of methods. The studies will be compared based on method as well as the granularity of analysis (POI level cost vs regional market level benefits for example).

## 6. Environmental and Siting Considerations

1. Comparison will outline how spatial planning of cable corridors is approached by each study including spatial analysis, cable routing priorities, and how minimizing cable distances or number of cables was incorporated into models.

Each theme was analyzed within both studies and then compared side-by-side to assess alignment, tension, or complementary insights. The focus of this analysis was on identifying common recommendations, differences in assumptions or approaches, and opportunities for integration into future planning and decision-making. Special attention was given to points of alignment that could support emerging best practices in interregional planning, and to unique insights that one study may offer that the other doesn't consider. Rather than evaluating the studies solely on methodological rigor, this analysis centers on establishing a common understanding of how their findings and frameworks can inform ongoing planning efforts. The goal is to bridge these approaches to offer a more complete foundation for discussions about coordinated, cost-effective offshore transmission planning across jurisdictions for a novel interregional system. This analysis is limited to the publicly available versions of both studies as of August 1, 2025. Findings should be understood as an interpretive synthesis of each study's published content.

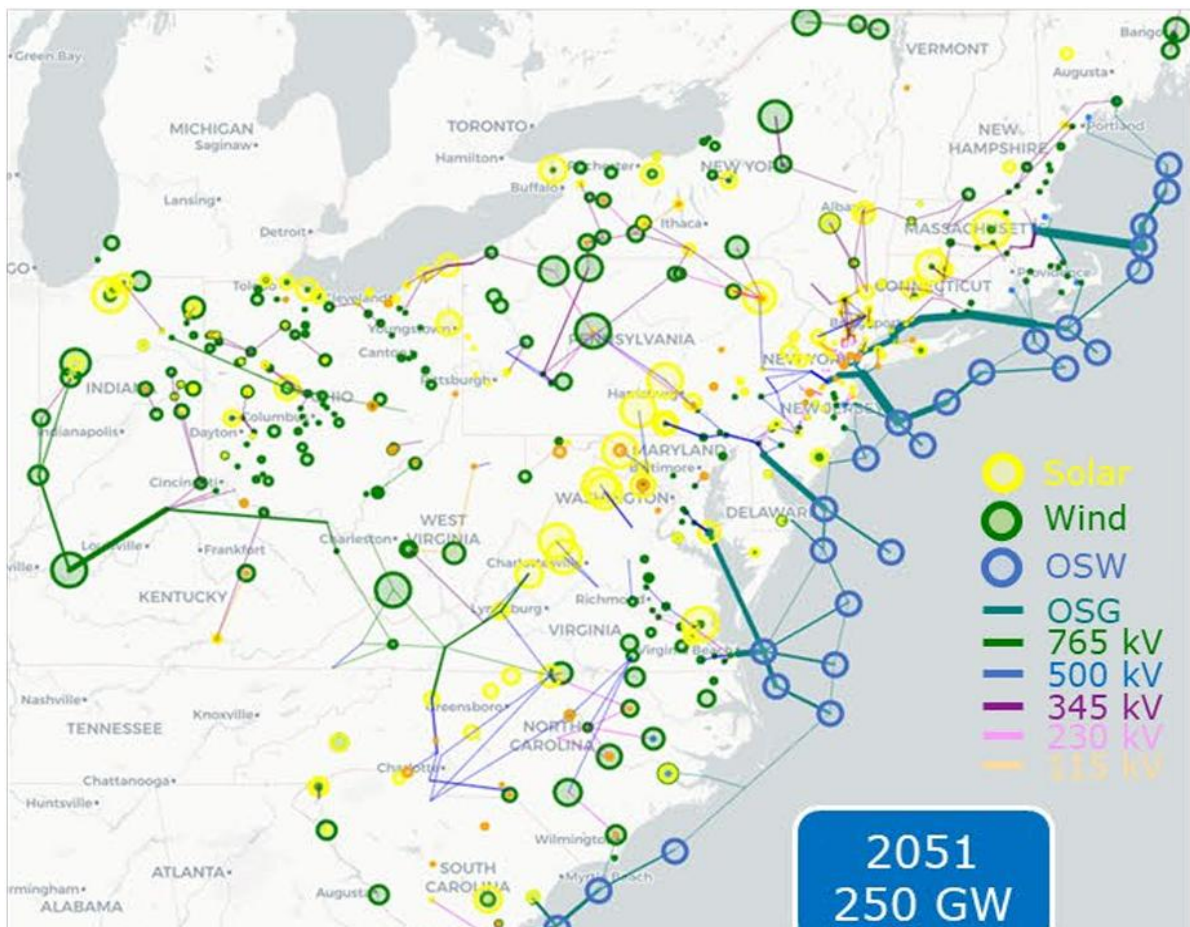
## Chapter 4: Comparative Analysis Results

Both studies found that the incorporation of 85 GW (or more) of offshore wind along the Atlantic Coast is an economic and viable path for decarbonizing the electric grid when leveraging offshore transmission to increase interregional transfer capacity. Within this common finding, each study has notable topline conclusions for offshore wind transmission expansion planning. The OSPRE study finds that to decarbonize the grid, deploying 250 GW of offshore wind minimizes the total investment in transmission by balancing the prevailing power flows. At 250 GW, major East Coast load centers can be served primarily by offshore wind, thereby minimizing onshore AC transmission expansion otherwise needed to bring inland onshore wind and solar from the west to coastal load centers. Figure 3 shows the land-based transmission and generation investments for this 250 GW, including the onshore investments in solar and onshore wind determined by a variation of capacity expansion modeling and corresponding transmission investments (described in more detail below in discussion of the modeling process). The figure shows that at this level, the model chooses to build an offshore transmission backbone, creating interregional transmission with high capacity connections to the grid. By using high capacity HVDC systems, including higher capacity POIs and cables than current practice, the study makes the case for scalable and standardized technology use to minimize environmental impact and optimize transmission investment. Considering offshore deployment at this level eclipses current deployment goals and encourages decision makers to think more broadly about optimal long-term coordinated transmission planning.

The DOE study finds that for 85 GW of offshore wind, transmission topologies that connect East Coast planning regions have benefits that exceed the costs by 2.7 times or more. The interregional topology shown in Figure 4 was found to have the greatest benefit to cost ratio

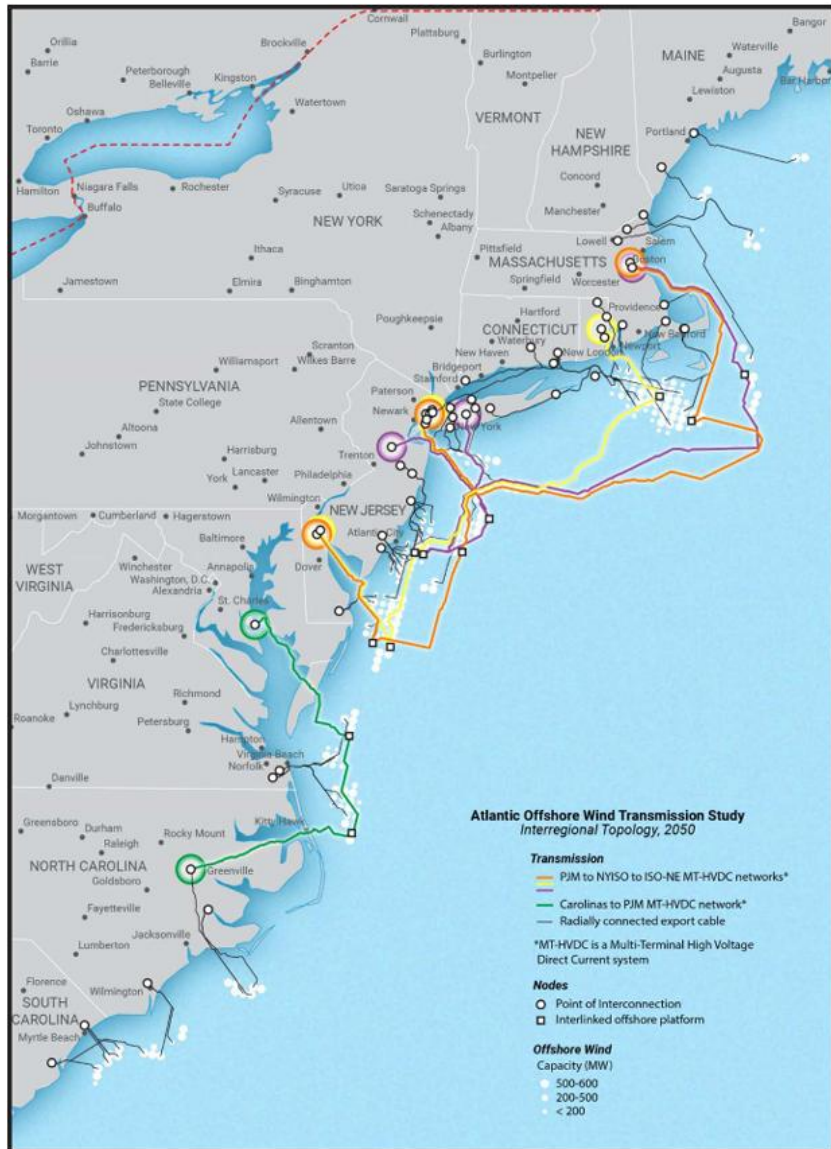
of 2.9, with connections made from ISO-NE to NYISO and PJM as well as PJM to the Carolinas in the Southeast. In this topology there is a combination of interregional connections and radial links that results in the highest benefit to cost ratio by optimizing total transmission investment, market benefits, and grid benefits. While the topology shown in Figure 4 has the highest benefit cost ratio, each of the five potential topologies for offshore wind transmission studied using capacity expansion modeling, production cost modeling, grid stability, grid reliability, and environmental siting considerations had ratios that exceeded 2. This finding illustrates that a coordinated approach to transmission can strengthen the transmission system, realize the benefits of interregional grid connectivity, and be deployed within existing siting constraints.

**Figure 3.** 250 GW transmission and generation investments.



*Note.* From Offshore Wind Transmission Expansion Planning for the U.S. Atlantic Coast. Hines et al, 2025, page 62 (<https://tufts.app.box.com/v/osw-ospre-2025-01-v11-trans>). Reprinted with permission.

**Figure 4.** DOE interregional topology for 85 GW OSW.



*Note.* From Atlantic Offshore Wind Transmission Study. Brinkman et al, 2024, page.xi (<https://research-hub.nrel.gov/en/publications/atlantic-offshore-wind-transmission-study-us-department-of-energy>). In the public domain.

A significant study difference is the scale of OSW injection. The DOE studied deployment of 85 GW on the Atlantic Coast by 2050 with a 95% carbon emissions reduction in the grid by 2050<sup>2</sup>. The OSPRE study uses three separate power flow models that each have

<sup>2</sup> The Biden-Harris administration set a goal of 110 GW of OSW nationally by 2050 with 85 GW targeted for the East Coast (Brinkman et al., 2024).

distinct goals. Two of these models analyzed similar injection levels of OSW by 2050 (both 85 GW and 100 GW), and one of these also studied injections of OSW ranging from 0 to 600 GW by 2050. By modeling up to 600 GW of OSW deployment, the OSPRE team created a suite of results that study greater injections of OSW than have been considered on the Atlantic Coast. This allowed for a range of results that exceeds the 85 GW of the DOE study. The third model studied transmission expansion on a nation-wide scale (as opposed to the Eastern Interconnection used in the other models) to create a Macrogrid, a grid connecting the country with high voltage transmission lines with an offshore transmission backbone as an Eastern leg of the Macrogrid.

Modeling a 90%+ grid decarbonization from 2030 levels by 2050 is a key driver of the results from both studies, motivating the expansion of offshore wind alongside onshore wind and solar while retiring, ceasing, or limiting investment in fossil fuels like coal, oil, and some natural gas technologies. With this common motivation, the studies take distinctly different approaches to modeling transmission expansion while ultimately concluding that offshore wind is an economic, and necessary, way to progress grid decarbonization at 90-95% decarbonization levels from 2030, and identifying that significant cost savings can be realized with coordinated interregional transmission planning and POI selection. While there are shared high level conclusions, the two studies developed distinct and separate results that speak to the relative strengths of each model.

The subsequent sections will describe in more detail the assumptions, and outputs, focusing on key areas impacting planning discussions today in the categories of:

- a. Modeling process and expansion sequencing (including assumptions and parameters and choosing POIs),
- b. Power flow analysis,

- c. Transmission technology type and cost,
- d. Cost modeling, and
- e. Environmental and siting considerations

## 4.1 Modeling Process and Sequencing

At their core, the two studies determine where offshore transmission is connected to the grid and how transmission build decisions are made based on fundamentally different modeling processes. The following sections will discuss the specific comparison of modeling details and outputs in the categories for comparison, but the sequence of steps in each model is equally important to understand how the studies differ

### DOE Modeling Process

The DOE model starts with a path routing methodology based on 26 layers of spatial data, each of which is assigned a friction or exclusion to determine suitability for a cable corridor. This methodology determines the most suitable cable corridors between lease areas and onshore POIs, forming a radial topology reference case (discussed further in 4.1.2). From the radial topology, the DOE uses the ReEDS (Regional Energy Deployment System) capacity expansion model, which optimizes investments for generation and transmission capacity to meet assumptions about future electricity demand, fuel prices, technology cost and performance, and policy requirements (Ho et al., 2021). The ReEDS capacity expansion process modeled generation capacity for a full range of technologies (including offshore wind, onshore wind, solar, coal, nuclear, natural gas, coal, hydropower, and other) in 2-year periods over the course of 20 years (2030-2050). The model chooses to invest in the most economic generation sources for the determined constraints, resulting in capacities of each source that is used to meet grid

demand over 20 years. The reference case for following steps was a low carbon scenario, which chose to invest in solar, onshore wind, storage, hydrogen turbines, and natural gas with carbon capture and sequestration.

The study then translates the ReEDS generation expansion results (technologies and associated capacities) into PLEXOS, a software used for production cost analysis (which studies how generation technologies are dispatched to meet load requirements given generation cost and transmission constraints). The study leverages the Multiregional Modeling Working Group (MMWG) 2031 scenario, a high-resolution power flow of the Eastern Interconnection, to create a detailed production cost model for the radial topology (Brinkman et al., 2024). The resulting hourly energy prices at each POI in the radial topology are used to create links between regions, prioritizing connections between the highest price differentials to enable replacement of high-cost generation in one region with low-cost in another. Using the price differential priority and minimizing the cost and distance of cable connections, the team created five transmission topologies for 85 GW of wind in 2050; radial, intra-regional (connections within one region), inter-regional (connections between regions), inter/intra-regional (a combination of within regions and between regions), and backbone (a continuous offshore transmission corridor from North to South). The benefit to the electric grid of each of these topologies is then quantified by another round of production cost modeling and resource adequacy modeling (how generation sources can be used to ensure sufficient electricity to meet demand). As a final step, the grid benefits of the five grid topologies are analyzed based on power flow models that study reliability and operability in steady-state and dynamic conditions.

### [OSPRE Modeling Process](#)

The OSPRE study comprises three power flow models developed by the Iowa State University team that are executed in parallel, each addressing separate questions about transmission expansion at different grid scales. The parallel function of these models produces three sets of transmission expansion results that can be used to corroborate similar results, address differences, and provide further context for expansion pathways. The scales of these models are described based on the number of buses (nodes where lines, loads, or generation sources are connected) in the model, which are used in power flow analysis to evaluate voltage, power flow, and/or generation at specific points in the grid.

Model 1 is a 90,059 bus model, referred to as the transmission expansion planning (TEP) model. Given the capacity of offshore wind, the TEP model chooses low-cost onshore POIs (substations) and associated capacities that minimize transmission expansion costs. Transmission expansion cost estimates, modeled as dollar/MW for each potential POI, include the cost of expanding the POI capacity, the cable from where it comes onshore to the POI (called a reach circuit), and onshore AC grid expansions to accommodate a higher capacity injection. The model is iterative, and each time the model chooses a POI and associated infrastructure expansion, those upgrades are included in the next iteration. The result is a sequenced list of POIs with capacity injection levels and a cost per MW to accommodate the injection.

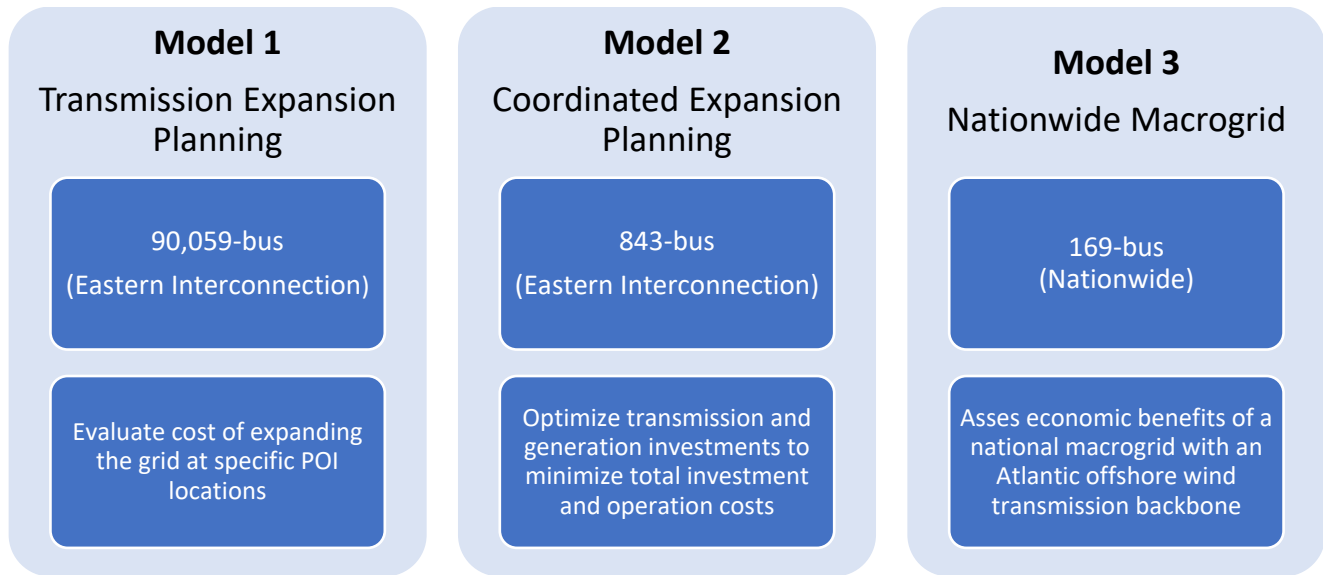
Model 2 started with a reduced 843 bus power flow model and a blank offshore grid template (OSGT) without requiring the use of specific corridors, POIs, or substations. Instead, a coordinated expansion planning (CEP) power flow optimization model builds out transmission lines and capacities from this empty template. The CEP model is constrained by carbon reduction (90%) and the amount of offshore wind being modeled (0-600 GW in 100 GW increments) then

identifies new investments (or retirements) in generation and transmission that minimize investment and operating costs over the planning horizon. This process results in a set of investments in generation sources which includes capacities for onshore wind, solar, and natural gas technologies, creating a set of generation sources that meet projected electricity demand. For a given scenario, the model invests in five-year increments (between 2031-2051), subject to limits on capacities for onshore wind, solar, and natural gas technologies. Investment caps in wind and solar resources are based on supply curves from a National Renewable Energy Laboratory study that consider both availability of resources and other exclusions that may impact energy infrastructure build out. There are three potential supply curves used that vary in extent of exclusions considered; Limited, Reference, and Open Access (Hines et al., 2025). This process results in transmission investments, POI capacities, and generation technology build out as a function of amount of OSW capacity.

Model 3, a high level 169-bus model, explores the development of a national HVDC Macrogrid, a nationwide grid that provides long distance, multi-regional, ultra-high transfer capacity, and envisions an East Coast offshore wind transmission backbone as a grid segment. Model 3 exceeds the geographic scope of both the other OSPRE models as well as the DOE study, using a national, reduced bus model to quantify the national benefits of a Macrogrid.

This comparative analysis will concentrate on Model 2 (CEP), which is the focus of the 2025 study paper, and use results from Models 1 and 3 to compare outcomes where relevant. Figure 5 outlines the three models, their granularity, and the primary objective of each.

**Figure 5.** Overview of OSPRE power flow models



*Note.* Three power flow models used in the OSPRE study with associated granularities and regions covered and main objective of each. Created by author.

#### 4.1.1 Assumptions and parameters

##### Planning Horizon

The studies use a 20-year planning horizon with a slight variation. The DOE study uses a 2030-2050 timeframe, and OSPRE uses a 2031-2051 timeframe, with each using five-year time increments for transmission investment or expansion. For this analysis, these time frames are considered functionally the same. Additionally, each team used a 2030 grid emissions baseline to model high carbon emissions reduction from the electric grid by 2050.

##### OSW lease areas and capacity

Both studies model offshore wind from the complete set of leases from the Bureau of Ocean Energy Management with the assumption that OSW areas that are not developed currently will be developed.

## Load and Weather data

Load modeling is used to project energy consumption rates in the electric grid over the planning horizon. Each study uses capacity expansion to study the relationship between meeting the load consumption with generation technology. The weather baseline impacts how offshore wind and other generation technology capacities are modeled. The approaches of each are outlined in Table 1. Figure 6 outlines the operational blocks for OSPRE over which generation, load, and transmission investment are modeled for.

**Table 1.** High level load and weather data sources

	OSPRE	DOE
<b>Load</b>		
Data source	FERC form 714: peak load FERC form 715: hourly load	ReEDS load data
Application to model	Distributed to reduced model buses 17 operational blocks created for each bus Model requires generation to exceed 115% of load in peak hours	Incorporated in ReEDS model as part of the capacity expansion modeling
Assumptions	4% growth per year 2031-2051 2% growth per year in Model 3	2.4% load growth per year
<b>Weather</b>		
Data source	NOAA 2020 HRRR dataset: 15 minute wind and solar profiles	2007-2012 county-level hourly weather profiles
Application to model	15 minute wind and solar profiles converted to outputs at each operating blocks	Converted to wind and solar production to generate capacity factors and outputs using Renewable Energy Potential (ReV) model

*Note.* Created by author

**Figure 6.** OSPRE Model 2 Operating Blocks

	Winter Dec-Feb	Spring Mar-May	Summer Jun-Aug	Fall Sep-Nov	Peak Load
11pm- 6am	1	2	3	4	17
7am- 1pm	5	6	7	8	
2pm- 6pm	9	10	11	12	
7pm- 10pm	13	14	15	16	

*Note.* Created by author

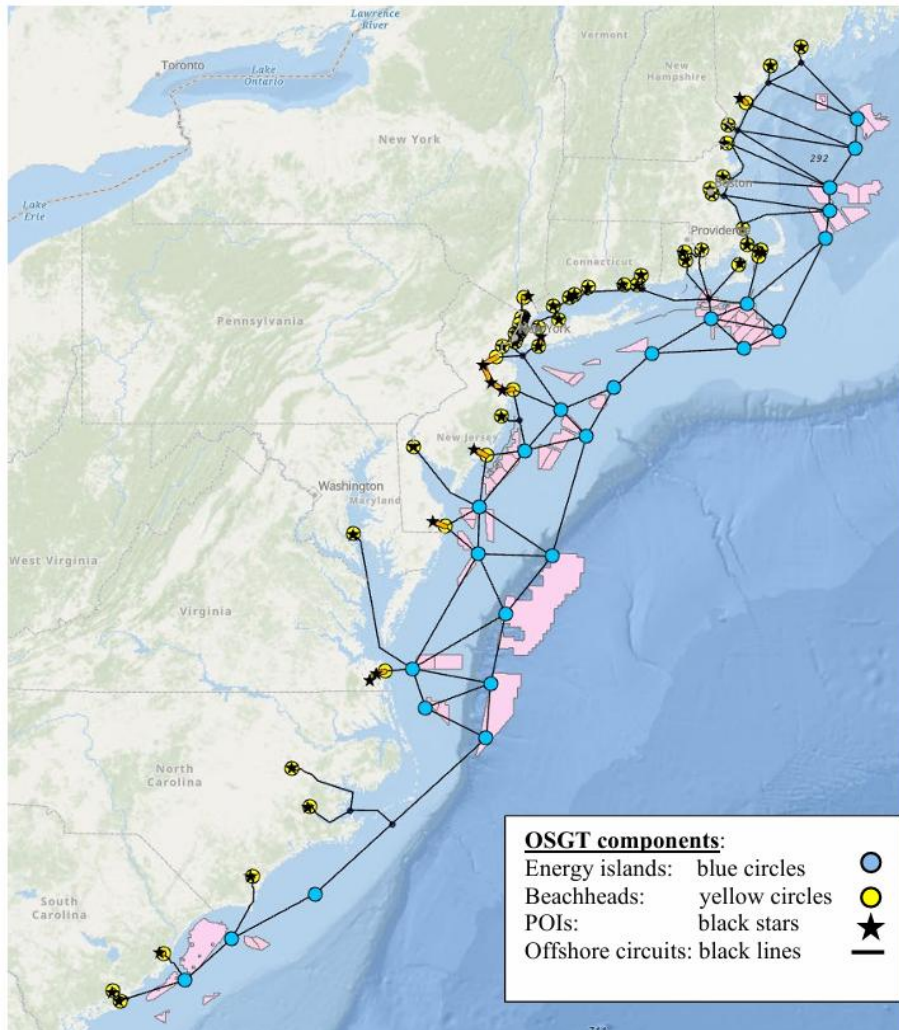
#### 4.1.2 Baseline grid topology

The assumptions for the layout of OSW transmission on the Atlantic coast have a significant impact on how offshore wind farms are connected to the main grid, known as topologies. The DOE study used a radial line base topology where each offshore platform area has an individual connection to the onshore electric grid. The study considered how to best optimize additional cables linking regions over the 20-year planning period but maintained the radial baseline in each build-out. This baseline was chosen based on current understanding of industry direction, and from platforms to POIs that were informed by the study’s technical review committee feedback (see 4.1.3, POI basis, below). With cables connecting each platform to a pre-determined POI, the baseline grid topology is not chosen explicitly by power flow, but instead by conversations about feasible POIs, a path routing methodology (see 4.5, Siting Considerations), and ensuring that each lease developer has a direct connection to inject power

into the grid. This analysis will primarily focus on the interregional and backbone topologies for comparison as they were found to have the highest benefit cost ratios (see section 4.4).

In comparison, the OSPRE study did not create topologies based on radial connections from each offshore platform. Instead, the study minimized the number of cables connecting onshore and studied topologies that allowed offshore cables between regions as well as an offshore backbone transmission corridor. The transmission expansion models did not assume specific cables at the start; instead, the model could choose to build cables from an offshore grid template (OSGT) comprised of offshore cables (circuits), energy islands, beachheads, and POIs, as seen in Figure 7. Energy islands are offshore substations where large injections of power are aggregated before being moved to shore and into POIs via high-capacity cables. This inclusion both removed the need for each wind lease area to have a direct path to shore and optimized for a single offshore wind backbone that connects these offshore nodes as North-South corridors are selected. Choice of technology and voltage level will be discussed further in 4.3, Technology Choice. Allowing the power flow models to choose the cables (both to shore and between platforms) that form the offshore grid for each level of OSW injection creates a grid that is based on power flow and minimization of cost.

**Figure 7. Offshore Grid Template**



*Note.* From Offshore Wind Transmission Expansion Planning for the U.S. Atlantic Coast. Hines et al, 2025, page 44 (<https://tufts.app.box.com/v/osw-ospre-2025-01-v11-trans>). Reprinted with permission.

#### 4.1.3 POI basis

Points of interconnection (POIs), the locations where power is injected into the grid, differ from the locations where cables land onshore, which will be referred to as beachheads. This section will focus on the choice of POIs; beachheads will be discussed in 4.5, Siting Considerations. Each study explicitly states that it does not constitute or replace the analysis and modeling that a transmission planner must conduct for an interconnection study. Interconnection

studies are explicit power flow models to understand a specific power injection at a single POI to understand the effect on grid reliability and stability, and what upgrades are needed to accommodate this injection safely. For each injection point of OSW into the grid, these interconnection studies will still be necessary in the future. However, each study modeled POI choice in a way that seeks to understand how injections of 85 GW or more power can be distributed across four different grid operating regions in a coordinated effort.

Comparing results from the DOE process to OSPRE Model 1 (TEP) presents a useful comparison of location and scale as both were incorporating 85 GW of OSW. Model 2 also studied POI injection choice and capacity that minimized transmission investment, this will be discussed further in section 4.2. The OSPRE study started with a list of 57 candidate POIs that the power flow model could ‘choose’ from, prioritizing those with existing capacity for OSW injections, closeness to shore landings for cables (called beachheads), and land availability for converter stations. A primary goal of this study was maximizing power flow injections at injection points in order to reduce total environmental impact . Without the requirement of a radial line from each OSW lease area, the model was free to choose power injections at POIs that could either handle a given injection or require the least cost upgrades to accommodate the injection. Prioritizing the choice of POIs based on power flow and minimizing costs allows the model to create a system that uses fewer POIs to accommodate the same GW of OSW.

The DOE began with a set of 61 candidate POIs, based on discussions with the study’s technical review committee and a series of reports that outlined feasible POIs for each region (DNV-GL, 2020; ISO-NE, 2024; North Carolina Transmission Planning Collaborative, 2022). Each POI was categorized by existing injection limit and upgrade cost (per additional MW of

injection). The per megawatt (MW) upgrade costs are sourced primarily from a paper written by the OSPRE study team describing results from OSPRE Model 1 results for 30 GW of offshore wind injections. Additional cost data for North Carolina was sourced from the North Carolina Transmission Planning Collaborative cost estimates (Brinkman et al., 2024). One primary difference from the initial OSPRE candidate POI list is the inclusion of 24 POIs for the 2030 scenario that were determined likely by the project team (based on existing literature and discussions with lease holders) and were required to be in the model. From this list of 61 POIs (including the mandatory 2030 POIs), the DOE team used a path routing analysis to determine POIs that minimize cable distance from lease areas to shore (and between POIs, for topologies linking regions). This path routing analysis will be described further in 4.5, Siting Considerations.

While both studies use a preliminary list of candidate POIs in their models, there are a few key differences that impact eventual topology and power flow results. The DOE study is not meant to be a suggestion for exact POI locations, instead, it serves as a representative model of where power could be connected to the grid. The study requires both a POI for each OSW lease area as well as an initial set of 24 POIs that must be included in 2030. These POIs are likely candidates to interconnect offshore wind based on industry expectations and consultations with experts. In contrast, the OSPRE use of candidate POIs, which are fed into a model, allows for flexibility and POI choices that are determined by power flow and the lowest-cost upgrade to accommodate injections. Without requiring a topology to have a set number of POIs, the OSPRE study chooses fewer power injection points with higher capacity injections, a method which minimizes onshore environmental impact. In practice, the study notes that POI choice depends on social acceptance, environmental review, and siting and permitting. While this section

presents an initial comparison of the approach for POI selection in each study and POI capacities, section 4.2 will present further context for the impact of power flow modeling on POI choices.

Table 2 outlines POIs chosen by the DOE interregional model for 85 GW and the OSPRE Model 1 76 GW of OSW. Shared choices are highlighted in green, the POIs required by DOE in 2030 are denoted with an asterisk. There is some overlap in POI choices, indicating a synchronization between the most cost-effective POIs for capacity upgrades and those recognized by industry and other stakeholders to be likely candidates for OSW injections. This result makes intuitive sense, as one primary consideration by stakeholders deciding likely POIs is whether they can handle the necessary injections or whether upgrade costs would be prohibitive. A key difference is in the number of POIs chosen, resulting from the modeling objective of the OSPRE study to minimize injection points while increasing POI capacity and for the DOE team to include a POI for each OSW lease area.

Of note, both studies have allowed injections above 1200 MW (1.2 GW), the single-source contingency limit (SSCL) for ISO-NE, NYISO, PJM, and the Southeast. The SSCL is a ceiling for the maximum amount of power that can be injected into any point on the grid to limit a single loss of power which could result in voltage collapse (Oberlin, 2023). This is currently set at 1200 or 1300 MW on the Atlantic Coast with the purpose of preserving grid reliability and was set in a joint agreement between ISO-NE, NYISO, and PJM. In 2023, the Transmission Planning division of ISO-NE requested that the Joint ISO/RTO Planning Committee for ISO-NE, NYISO, and PJM, study whether raising the SSCL from 1200 MW to 2000 MW in New England is technically feasible without interrupting grid stability or reliability, and if not, what additional

steps would be necessary (Oberlin, 2023). This request came as the Atlantic Coast is considering large injections of renewables like offshore wind, where a limit on the injection level at any point can significantly affect long-term transmission planning and prohibit what could be optimal interconnection levels.

**Table 2.** POIs for DOE and OSPRE Report Model 1 POIs for 85 GW.

DOE POIs	State	DOE MW	OSPRE Model 1 MW
<b>NYISO</b>			
Astoria*	NY	1230	
Barret*	NY	1350	
East Garden City	NY	2000	
East Hampton*	NY	140	
Farragut East*	NY	1310	4000
Farragut West*	NY	1310	4000
Gowanus*	NY	820	
Holbrook*	NY	1050	2000
Millwood	NY		6000
Mott Haven*	NY	2000	
Northport/Pilgrim	NY	1500	
Shore Rd	NY	1310	4000
Rainey*	NY	2000	
Ruland Rd	NY	2000	
W. 49th St.*	NY	1310	
<b>Total</b>		<b>19330</b>	<b>20000</b>
<b>PJM</b>			
BL England*	NJ	430	
Calvert Cliffs	MD	2000	
Cardiff*	NJ	1500	4000
Deans	NJ	3100	6000
Fentress*	VA	5200	4000
Hope Creek	NJ	2000	
Indian River*	DE	1600	2000
Landstown*	VA	2600	4000
Larrabee*	NJ	1300	4000
Oyster Creek*	NJ	820	
Salem	NJ	2000	
Atlantic	NJ	1200	
Smithburg*	NJ	2400	6000
<b>Total</b>		<b>26150</b>	<b>30000</b>

DOE POIs	State	DOE MW	OSPRE Model 1 MW
<b>ISO-NE</b>			
Barnstable*	MA	830	
W. Barnstable*	MA	840	
Block Island*	RI	30	
Bourne*	MA	1200	
Brayton Point*	MA	2330	
Card St.	CT		4000
Carver	MA		4000
Haddam Neck	CT	1200	
Davisville*	RI	720	
K Street	MA	2000	
Kent County	RI	1870	
Maguire Rd	ME	1200	4000
Manchester St	RI	1200	
Millstone	CT	1200	4000
Montville*	CT	800	
Mystic	MA	1990	
Norwalk	CT	1200	
Pilgrim	MA	1830	
Seabrook	NH	660	
Tewksbury	MA	1770	
Ward Hill	MA	1200	
West Farnum	RI	1200	
Woburn	MA		4000
Yarmouth	ME	1200	
<b>Total</b>		<b>26470</b>	<b>20000</b>
<b>South</b>			
Georgetown	SC	2400	
Greenville	NC	2850	
Myrtle Beach	SC	2400	
New Bern	NC	3200	
Sutton North*	NC	2200	2000
Winyah	SC		4000
<b>Total</b>		<b>13050</b>	<b>6000</b>
<b>EAST COAST TOTAL (GW)</b>		<b>85</b>	<b>76</b>

*Note.* Created by author using data adapted from “Offshore Wind Transmission Expansion Planning for the U.S. Atlantic Coasts” and “Atlantic Offshore Wind Transmission Planning Study”

As of May 2025, the JIPC study is incomplete but is studying the impact of raising the SSCL to 2000 MW in ISO-NE based on steady state and stability analyses, and indicated that there are no existing interconnection limits in NYISO and PJM that would prohibit 2000 MW injections (Vijayan, 2025). Additionally, ISO-NE recently released a study that found that there are POI options in New England that could incorporate up to 9.6 MW without any additional upgrades or transmission infrastructure that would need to be built, including several that could accommodate 2000 MW (ISO-NE, 2025). In a sensitivity analysis, the DOE study also found that decreasing injection points from 2 GW to 1.2 GW resulted in a 36% decrease in net annual value for the interregional transmission topology, indicating the necessity of higher contingency limits to realize the full value of interregional transmission. OSPRE goes a step further by allowing injections of up to 6000 MW (6 GW), which is far beyond that considered in the DOE study and the current standards on the East Coast. The upper bound of 6000 MW allowed for fewer injections, limiting environmental impacts. Further discussion of POI strength characterization is discussed in section 4.2.

The overlap in choice of POIs at 85 GW presents a useful basis for understanding tradeoffs of POIs such as the feasibility based on stakeholder discussion and least cost upgrades for high-capacity injections. The representative POIs in the DOE model illustrate how connections between regions can facilitate benefits while the iterative ability of the OSPRE models allows for studying numerous combinations of POIs and capacities under different constraints. The OSPRE study suite of tools can be used in dynamic discussions between technical and policy stakeholders about power flow impact of POIs while accommodating for limits on location due to siting constraints, state preference, or developer ability to interconnect. Integrating the siting constraints presented in the DOE study with the power flow of OSPRE

Models 1 and 2 would create an informed POI selection process that could be used to prioritize interconnection locations in a coordinated manner.

## 4.2 Power flow method

The OSPRE team uses three power flow models (briefly outlined in 4.1 and Figure 5) to determine transmission expansion investments, while the DOE study uses power flow as a grid stability and reliability assessment after transmission topologies have been formed. In this way, power flow modeling plays functionally different roles in each model by determining investments and grid topology in the OSPRE model and verifying grid functionality and benefits in the DOE model. While the DOE capacity expansion model does incorporate power flow modeling, it uses a model known as a ‘copper plate’ model, a way of representing power flow as a set relationship between two points, as opposed to modeling the flow and behavior of the electric grid (Neumann et al., 2022). Thus, in the initial DOE capacity expansion, specific grid behavior is not modeled. Instead, after the radial topology was created, capacity expansion and DC power flow were used to expand the MMWG 2031 into a feasible 2050 transmission grid used as the basis for verifying grid reliability, stability, and strength. This base model is used in the study’s initial production cost modeling of the radial topology as well. The MMWG develops power flow and dynamic models to simulate steady state and dynamic grid behavior in the Eastern Interconnection. An overview of the key models used by both studies is provided in Appendix A to provide a quick reference for comparison of key model objectives and details.

Appendix B contains maps of topologies created by the OSPRE power-flow models that can be compared with the DOE methodology, highlighting the key difference in choice of topology expansion. Figure 9 (OSPRE Model 1, 85 GW) and Figure 10 (OSPRE Model 2, 100

GW) in Appendix B depict the topologies chosen by power flow expansion models in the OSPRE study. When compared with Figure 4, the interregional topology for the AOSWTS 85GW, the differences in offshore transmission corridors and POIs are apparent. The DOE interregional topology is depicted here for the sake of comparison though the methodology focused on capacity expansion and production-cost modeling with selective power flow to enhance topology decisions.

Section 4.1 outlined how POIs were chosen, but each study also used power flow to characterize POI strength to understand the impact of choice of POI on grid function. OSPRE Models 1 and 2 each characterize POI strength through expansion costs and injection capacities . ‘Strong’ POIs in Model 1 are indicated by low cost per MW expansion (\$/MW) while ‘strong’ POIs in Model 2 are indicated by higher capacity injections. Conversely, the DOE’s grid strength analysis characterized strength of a subset of the pre-selected POIs using the base industry power flow model to determine the short-circuit ratio, a metric for whether a system can maintain stability during disturbances (Osman et al., 2018). The variation in scale of models, amount of OSW injections (30-250 GW), and POIs studied make a direct comparison of the strength of specific POIs infeasible, but there are conclusions that highlight important considerations for planning conversations.

The OSPRE study evaluated whether the models agreed on POI strength based on the relationship between cost per MW from Model 1 and amount of injection from Model 2. POIs with high-capacity injections were expected to have low expansion costs, and vice versa. The relationship behaved as expected in general, indicating reasonable agreement and providing a subset of POIs characterized as strong by both models. However, only OSPRE Model 1 includes

contingency planning which is a fundamental part of grid reliability standards that indicates whether a grid is able maintain stability in operation after a contingency event (losing a transmission line, a generator, or other key infrastructure) (IEA, n.d.). DOE's analysis of grid strength at POIs determined the short circuit ratio at N-0, N-1, and N-2 contingencies for a selected subset of POIs at 30 GW of OSW. There was a significant decrease in POIs classified as strong between normal operating conditions (N-0) and contingency conditions (N-1 and N-2), indicating a need for appropriate grid strengthening measures to incorporate 30 GW or more of OSW. The analysis in each study has limitations, with DOE only modeling for a subset of injections at 30 GW and the OSPRE study not incorporating contingencies in both models.

The OSPRE Model 3 for a nationwide Macrogrid (a scale of modeling that is not included in the DOE study) creates important context for the results of the other power flow models. Interregional transmission on this scale has been considered by multiple studies and found to have significant benefits as quantified by cost to benefit ratios, but none have incorporated this level of OSW (Bloom et al., 2022; P. R. Brown & Botterud, 2021; United States Department of Energy, 2023). This scale of modeling finds that for both 85 GW and 250 GW of OSW integration, the total cost for the Eastern Interconnection transmission build out is reduced by \$45 billion. This cost reduction is primarily a result of reduced need for onshore AC transmission expansion or upgrades and increasing access to resource diversity nation-wide (as opposed to local generation build).

The suite of tools produced by both studies can be used in concert to create a transmission system guided by power flow and verify grid system function in dynamic and steady state analysis on an Eastern Interconnection Scale. The OSPRE models are intended to be used iteratively with flexible constraints, inputs, and assumptions. In dynamic planning conversations this ability is crucial to enhance understanding of the impact of specific assumptions. For example, the POI inputs for Model 1 and 2 could be limited or constrained based on state and industry feasibility input and then rerun, producing cost estimates, transmission investment, and generation investment choices that more accurately reflect conditions that stakeholders are working with.

#### 4.3 Transmission technology type

The technology choice in these studies impacts the chosen offshore topologies, the cost estimates, and relevant onshore transmission system considerations (necessary substation upgrades at POIs, for example). As a result of the size and investment scale of offshore wind, combined with the interregional potential, technology choice is an ongoing discussion for the industry, especially as it relates to creating adequate supply chains (Shields et al., 2022). However, there has been a unified move to standardize components of offshore wind transmission systems, allowing for a streamlined supply chain, ease of planning, and allowing for interoperability in interlinked or meshed transmission systems like those described in each of these studies. These two studies have both emphasized the importance of creating standardized technology choices as well, although the specific choices and assumptions vary.

The OSPRE models use technology choices that allow for scalable and interoperable design while enabling high-capacity corridors and thus minimizing the number of corridors. The

DOE study also emphasizes the importance of standardized and interoperable design but, because the topologies include more cables bringing power to shore, it does not prioritize the high-capacity corridors envisioned by OSPRE until 2030 or later. Part of the design inspiration for the high-capacity system used by OSPRE is the TenneT 2GW scalable offshore wind system. TenneT, the first cross border transmission system operator for Europe between Germany and the Netherlands, has developed this system as part of a high-capacity commitment between Belgium, Denmark, Germany, and the Netherlands to deploy 65 GW of OSW production by 2030 (exceeding the European Union’s goal to deploy 60GW of OSW by 2030) (TenneT 2GW Program, n.d.).

The 2GW system, shown in

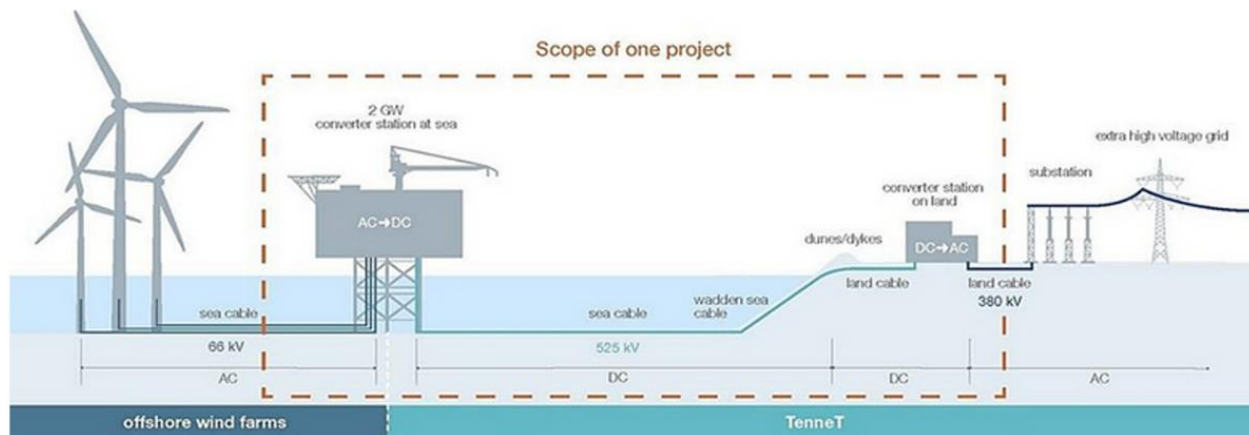
Figure 8. *TenneT 2GW standard diagram* uses a standard design of a 2GW offshore platform that aggregates power from multiple OSW farms using AC cables and then transmits it to shore with a 525kv HVDC bipole cable. These 2GW systems are also able to interconnect offshore via HVDC cables, facilitating multiterminal grid (as opposed to a radial cable only grid). Between Germany and the Netherlands, this design is currently planned for 28GW of OSW with 18GW deployed by 2030. This design not only increases capacity brought to shore while minimizing space use and thus environmental impact but also creates a technology standard and shared process to enable volume procurements and facilitate an interlinked offshore grid<sup>3</sup>. The 2GW standard system is assumed as the basis of the offshore grid and implemented in the OSPRE

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<sup>3</sup> The European project “Enabling interoperability of multi-vendor HVDC grids” ([InterOPERA](#)) is defining technical frameworks and standards to ensure HVDC transmission from different suppliers is interoperable. In the 2023 workshop at Tufts University on preliminary Model 1 findings, participants discussed modeling a U.S. adaptation of this process at the federal level.

study use of energy islands, offshore substations where 2GW of OSW is aggregated before being transmitted to shore. Similarly, this study focuses on enabling 525kv HVDC bipole cables.

**Figure 8.** TenneT 2GW standard diagram



*Note.* Illustration of the TenneT 2GW standard used in the OSPRE offshore wind transmission workshop in June 2023, adapted from TenneT documentation by Clemson University researchers. From East Coast Offshore Wind Transmission Workshop Brochure. Harris et al, 2023, page 2 (<https://tufts.app.box.com/v/osw-east-coast-osw-trans-2023>). Reprinted with permission.

DOE’s study uses a combination of cable technologies and voltages that reflect current planning within the United States, such as the meshed grid readiness requirements in New York that considers combinations of HVAC and HVDC technology at varying voltages (Gnanarathna et al., 2023). In the base radial topology, radial lines to shore were individually assessed based on distance from shore (including routing feasibility), and capacity of the OSW generating area. Export cables were then assigned using a 220kV HVAC cable, a 320kv HVDC monopole cable, or a 525kV HVDC bipole cable (the level used in the OSPRE study). Topologies still use the baseline radial topology so in each scenario there is a mix of voltage class for both HVDC and HVAC technology. Further, the study is assuming that up until 2030 there will only be HVAC or 320 kV HVDC and only consider 525 kV HVDC technology after 2030. The modeling impact of

this assumption is that the interregional and backbone topologies require multi-terminal HVDC technology to be deployed starting in 2030 to realize the benefits studied.

Multi-terminal HVDC is necessary to realize the full benefits of an offshore grid. Technology standardization is essential for strengthening an HVDC supply chain and building an offshore grid, a finding that has been echoed in OSW planning discussions outside of these papers (Baranowski et al., 2022; Shields et al., 2022). The OSPRE study can minimize space use (number of cables and POIs) because it uses uniform 525kV HVDC cables to inject much higher capacities at fewer points and incorporates offshore energy islands that ‘collect’ power before transmission to shore. The expansion of standardized, modular, HVDC offshore systems in Europe offers a template to be adapted to the United States to ensure that offshore grid build out is expandable, compatible, and interoperable.

#### 4.4 Cost modeling

The modeling sequence in each study determines how cost optimization is built into valuation of the transmission topologies. As outlined previously, the OSPRE models combine power flow modeling with cost optimization. Cost parameters (such as capital costs and operation and maintenance costs) for candidate transmission lines (onshore and offshore) are inputs to the optimization that jointly balances transmission investment and power flow. In other words, the cost model is structural and embedded within the optimization, as opposed to a valuation added after a topology was selected. The AOSWTS determines generation investments (while requiring 85 GW of OSW) through capacity expansion and then uses a path routing methodology based on existing understanding of likely POIs and modeled space use constraints. With a base radial topology established, additional links between regions are created where price

differentials between POIs indicate potential for market value of connection, a consideration that is not applicable in the OSPRE study. For each topology, the study then computes engineering costs (cables, converters, substations, and upgrades) based on candidate routing and capacities. Then each scenario is put through a production cost model and power flow simulation to estimate benefits (reduced curtailment, avoided fossil generation, reliability contributions, and congestion savings for example).

Both cost modeling processes have relative strengths as each study aims to develop a cost-effective transmission solution for offshore wind, but each is optimizing cost for different purposes and at different points in the modeling flow. The OSPRE study builds a transmission system that minimizes total investment and operation costs over the course of the 20-year planning horizon while the DOE study develops topologies, partially based on geographic differences in cost of energy, and then evaluates costs and benefits (grid reliability, resource adequacy, etc.) for each. As a result, the DOE study found that each of the five topologies studied resulted in benefit-cost-ratios of over 2, with interregional and offshore backbone topologies having benefit-cost-ratios of 2.9 and 2.7 respectively.

The OSPRE study finds that 250 GW of offshore wind minimizes land-based transmission investments is an important indicator about how OSW fits into broader grid planning initiatives. At this level of OSW injection, coastal loads are met with offshore generation and there is not an excess of power that requires transmission further inland. Thus, investments are minimized because there is no need for additional transmission to bring onshore renewables to coastal areas or transmission to bring surplus OSW to inland loads. Shifting OSW transmission planning from a project-by-project interconnection into a part of optimization of

power flow in the Eastern Interconnection supports a higher level of OSW integration than previously considered.

In the Model 2 iteration for 100 GW of OSW, there are sizable transmission investments in Pennsylvania, New York, and Illinois to bring onshore wind to coastal load centers, a finding that is reflected in production cost modeling by the DOE. As part of a sensitivity analysis for the interregional topology, DOE finds that the greatest value addition for the offshore interregional network at 85 GW of OSW is expanding the onshore AC transmission grid to access onshore renewables in the western PJM planning area. While the two studies are for slightly different amounts of OSW the findings are complementary, that for 85-100 GW of OSW, cost effective generation and transmission dispatch for a decarbonized grid will require onshore transmission build out to leverage western onshore renewable resources.

The findings from these studies at this scale are the first to verify that coordinated planning for offshore transmission results in net benefits and further, that there are ways to minimize investments to achieve these benefits. Both the DOE's production-cost model and the OSPRE CEP model concluded that at levels around ~100 GW of OSW, onshore transmission investment is required to meet decarbonization goals. Planning for higher OSW injection than previously aimed for by previous federal or state goals is a paradigm shift for how transmission planning is considered in efforts to decarbonize our grid, shifting from a project first process to a holistic effort of optimal grid expansion.

#### 4.5 Siting and environmental considerations

Both the OSPRE and DOE studies have sought to balance the space use required by an offshore transmission system with environmental considerations while specifically noting that

they do not constitute or replace the environmental review and in-depth siting and permitting studies that will be necessary to determine transmission corridors. Both use this environmental consideration as a model basis but diverge in methods. As mentioned in previous sections, the OSPRE model is based on minimizing environmental impact, which is inherently built into the models by using a smaller number of high-capacity cables, aggregating offshore cables at energy islands, and prioritizing POIs with adequate space for expanding converter stations (judged by visual inspection of satellite imagery). Similarly, the initial OSGT used in Model 2 used submarine routes in waterways where possible to avoid onshore siting constraints. However, the study specified that the cables, POIs, and beachheads selected by models are not specific corridors or areas that have been deemed ‘sitable’ and note that in practice some of these may be unsuitable due to environmental, social, or regulatory pushback. However, this model sets a standard for a system that not only seeks to operate within space constraints but also to minimize the total space needed for these systems.

The DOE created a tool based on 26 layers of siting constraints, environmental considerations, or space exclusions. The tool then categorized offshore space areas based on levels of friction (the relative difficulty or limitations of placing a corridor in that area) or exclusion (areas that transmission cables cannot pass through) assigned to each layer by the project study team. The result of this classification system is shown in Appendix C, depicting areas for cable corridors on a scale of less to more friction with exclusion areas shown in black. The 26 offshore data layers, shown in Appendix D with data sources, consisted of spatial data in geology, regulatory, shipping and navigation, and physical structures. The study also leveraged previous research done for onshore transmission siting constraints as they related to onshore wind development, consisting of 17 onshore considerations layers, including protected land,

physical structures, regulatory barriers, and other environmental considerations (Lopez et al., 2021). The path routing methodology that DOE used studied all potential paths between offshore wind locations and POIs, creating a set of potential corridors that have been optimized for the shortest distance with the fewest frictions and exclusions.

The space use constraints from the DOE, shown in Appendix C, are a complete view of the complex ocean co-uses that must be considered in future routing of export cables to beachheads. Appendix C contains both the final exclusion and space use friction values for the East Coast (Figure 11) and space use constraints by region (Figure 12). Considering methods for routing cables within constraints is feasible but establishing coordinated transmission planning that minimizes the number of cables can reduce overall space impact and the number of cable corridors needed for an effective offshore grid. To achieve a decarbonized grid, investments in offshore or onshore low-carbon generation sources are necessary, both of which require transmission. Using the combination of least-cost total transmission investment from the OSPRE Model 2 with the siting constraints analysis by the DOE study present a system that both minimizes the total use of space while considering transmission within feasible corridor routes. In depth siting and permitting studies are necessary for every cable corridor, but envisioning the system on this level is necessary for efficient and environmentally conscious use of space.

#### 4.6 Results Summary

Tables 3 and 4 present the study comparison in a condensed format for use as reference in iterative discussions about study results.

**Table 3.** Topline study comparison

	<b>DOE: Atlantic Offshore Wind Transmission Study (AOSWTS)</b>	<b>OSPRE: Atlantic Offshore Wind Transmission Planning</b>
<b>Modeling Comparison</b>		
Purpose / Objectives	Evaluate coordinated transmission pathways (radial, backbone, interregional) to enable large-scale OSW deployment (through 2050) along the U.S. Atlantic coast; assess benefits and costs, grid reliability impacts, environmental and siting constraints; inform federal/state decision making.	Study transmission expansion planning models and frameworks for optimizing coordinated transmission investment for OSW. Develop models for a high capacity onshore/offshore integrated grid, providing tools and results for iterative planning discussions among transmission planners and decision makers.
Geographic Scope	Atlantic Coast from Maine to South Carolina (offshore + onshore).	Atlantic Coast from Maine to South Carolina (offshore + onshore). Includes high level national model for Macrogrid modeling.
Grid Decarbonization	By 2050: 95% from 2030 levels	By 2050: 90% from 2031 levels
Scale and Scenario Variants	2030-2050 planning horizon; sequenced deployment from 0 GW up to 85 GW	2031-2051 planning horizon; OSW integration of 0-600 GW of OSW to test optimal transmission investments and existing grid capacities
Transmission Topology	5 topologies studied with radial export cables as base for each; radial, intraregional, interregional, inter/intra-regional, and shared offshore backbone	Topology determined by model as a function of OSW amount; backbone with offshore power aggregation; scalable expansion design to minimize number of cable corridors and points of interconnection, considers national Macrogrid
Modeling Process (Simplified)	<ol style="list-style-type: none"> <li>1. Path routing analysis through siting and environmental constraint layers</li> <li>2. Capacity expansion modeling</li> <li>3. Transmission technology choice and valuation</li> <li>4. Production cost modeling</li> <li>5. Grid stability and reliability power flow simulations</li> </ol>	<ol style="list-style-type: none"> <li>1. Transmission technology choice and valuation</li> <li>Then in parallel:</li> <li>2. Least cost transmission expansion planner (TEP) at POIs for 85 GW</li> <li>3. Coordinated expansion planning power flow optimizer (CEP)</li> <li>4. HVDC Nationwide Macrogrid benefit valuation</li> </ol>
Power flow analysis	Eastern Interconnection Reliability Assessment Group's Multiregional Modeling Working Group power system models used to evaluate reliability and stability of each grid topology under a variety of contingencies	AC and DC power flow tools developed by research team at 3 planning granularities, integrated power flow with economic optimization. TEP chooses transmission builds that minimize total costs for 0-600 GW of OSW and CEP chooses least cost POI upgrades. Macrogrid evaluates grid benefits of national interregional HVDC transmission pathways
Transmission Technology Choices	220kV HVAC, 320kV HVDC, 525kV HVDC export cables HVAC and HVDC interlinks	525kV HVDC cables (export cables and interlinks) 2 GW offshore energy islands
Cost modeling	Capacity expansion modeling determines new infrastructure to meet demand at the lowest cost, electricity market price differentials used to form interregional connections, production cost modeling quantifies grid benefits	Technology and transmission expansion costs built into power flow models, choices for transmission investments made based on minimizing total investment and operation cost over planning horizon
Environmental & Siting Constraint	Path routing methodology is based on 26 layers of environmental and ocean co-use constraints and exclusions (marine protected areas, military zones, shipping lanes etc.)	Models inherently choose high capacity lines and POIs to minimize cable corridors and reduce environmental impact

**Table 4.** Topline study result comparison

	<b>DOE: Atlantic Offshore Wind Transmission Study (AOSWTS)</b>	<b>OSPRE: Atlantic Offshore Wind Transmission Planning</b>
<b>Key Results</b>		
Outputs	Greater than 2x BCR for each topology, 2.7+ BCR for interregional and backbone topologies; phased build-out reduces development risk; interlinks yield highest value	250 GW OSW deployment level minimizes land-based transmission upgrade investments; cost effective POIs are closest to major load centers; Macrogrid can facilitate high levels of OSW deployment
Recommendations	Early standardization of HVDC essential; increase single source contingency limits; onshore transmission to maximize renewable integration	Early standardization of HVDC essential; increase single source contingency limits and use of remedial action schemes to allow fewer high capacity POIs
Strengths and Advantages	Detailed consideration of environmental constraints; quantification of costs and benefits for each modeled topology including grid stability and resource adequacy	Land-based grid modeling of integrated power flow/cost optimization, 3 scales of modeling, scalable grid design, expanded range of OSW injections modeled
Limitations and Caveats	Power flow used primarily as verification of grid function; uncertainty in exact interconnection points; does not include cost allocation methods	Less detailed inclusion of potential environmental and siting constraints; contingency modeling not included in all models; does not include cost allocation methods

*Note.* Created by author

## Chapter 5: Discussion

This analysis compares two East Coast offshore wind transmission studies in key study areas to help enable responsive analysis transmission planning conversations. The studies can be viewed as a comprehensive suite of tools, models, and analytic capabilities that can be leveraged for ongoing iterative discussions between technical planners, offshore wind developers and industry, policy-makers, and other decision-makers. The strength of these studies is in their separate, often complimentary, approaches to considering a future transmission system for OSW.

### 5.1 Key Shared Findings

1. Offshore wind is an economic, and necessary, part of the generation mix for achieving 90%+ decarbonization levels in our electric grid by 2050.

Achieving an electric grid that meets decarbonization goals on the East Coast while expanding generation sources that keep consumer costs minimal will require offshore wind. Capacity expansion modeling, widely used in grid planning to ensure that generation and transmission buildout meets future load needs, shows that offshore wind is economic in both scenarios that constrain the amount of offshore wind that is built as well as those that don't set specific generation requirements aside from decarbonization goals.

2. Leveraging offshore transmission to create interregional transmission (with necessary onshore transmission expansion) enables greater grid benefits and minimizes transmission costs.

Considering OSW transmission as part of an 'ideal' power grid (instead of on a project-by-project basis) results in a least-cost system that minimizes total costs. There are greater than 2x benefits for topologies that leverage interregional transmission. These findings are timely and applicable for regional efforts between ISO-NE, NYISO, and PJM through the Northeast

States Collaborative on Interregional Transmission, that recently put out a Request for Information for interregional project concepts that enhance transfer capacity (MA EOEEA, 2025). The combination of tools, approaches, and findings in these studies are well positioned to translate study concepts into actionable projects that align with current regional transmission priorities.

3. For OSW amounts less than ~250 GW, onshore transmission expansion to access onshore wind energy in the Western Eastern Interconnection is necessary.

In a decarbonized grid, routing low-carbon generation will require transmission expansion whether onshore or offshore. This implies a tradeoff to be weighed by decision makers between generation type and transmission builds and the inherent difficulty with siting transmission onshore in difficult to site congested areas instead of developing offshore transmission corridors. While it doesn't overcome regulatory and policy barriers, envisioning higher OSW levels, as in the OSPRE study, indicates an optimal integration level that minimized total transmission build out and could alleviate siting and permitting difficulties.

4. Raising SSCLs to 2,000 MW creates greater grid benefits through increased interregional transmission capacity and fewer injection points for offshore wind.

The existing efforts in East Coast planning regions to raise the SSCLs from 1,200 to 2,000 are supported by the findings that higher injections both optimize power flow and maximize economic benefits of an interregional topology. Increasing SSCLs beyond 2,000, as indicated in the OSPRE work, would require the implementation of remedial action schemes that automatically detect grid abnormalities (like a voltage drop from the loss of a single source) and take a series of corrective actions to ensure grid stability and reliability (NERC, 2014).

These schemes are common in the West and the OSPRE report authors support implementation on the East Coast.

5. Offshore HVDC technology (cables, substations, etc) standardization is essential to creating a scalable system that ensures interoperability in a sequenced build out.

The first utility scale OSW was connected to the power grid in New York in 2023 using a 132kV cable, a voltage level lower than that modeled in each of these studies (Nexans, 2023). There will be transmission build out at lower voltages and capacities than outlined in these studies but planning future transmission at high capacities will minimize environmental impacts and strengthen the HVDC supply chain. Preserving pathways to HVDC multiterminal interregional transmission as future offshore power is connected will require standardization to ensure compatibility, interoperability, and expandability of transmission design.

#### Additional considerations

1. The tools created in both studies can be used to form the basis of a dynamic process between stakeholders to optimize transmission investments for a least-cost, least-regrets expansion pathway. Land based transmission investments for any given level of offshore wind can be modeled using the OSPRE Model 2 while siting constraints for offshore cables can be conceptualized with the DOE siting tool.
2. Modeling the East Coast offshore transmission build out on the 2 GW TenneT standard in Europe could strengthen a European American HVDC supply chain while creating transmission that minimizes environmental impacts using higher capacity corridors than have been previously considered.

3. Choice of POIs and their injection capacities have a significant impact on determining transmission topologies, power flow impact, and siting considerations. A framework that begins with predetermined POIs at lower capacities results in more cables and beachheads, requiring additional siting and permitting for each cable.

### Limitations and Future Research

This thesis is limited to a textual analysis of each report and establishing a basis for comparison between the two studies while limiting scope to focus on key comparison areas. As a result, there are topical and framework-based limitations to this work. Both studies were conducted in rapidly evolving regulatory and energy market environments. Policy changes such as updates to FERC Orders impacting transmission planning, Inflation Reduction Act implementation, and state-level offshore wind procurement updates may not be fully incorporated into either study's assumptions. The comparative framework developed is itself subject to limitations. The framework emphasizes specific categories, such as cost effectiveness, grid reliability, and environmental impact, but other important factors (for example workforce development, social acceptance, marine spatial conflicts) were not deeply analyzed due to scope constraints. This narrowed lens may simplify broader implications of transmission planning actions in these areas.

This comparative analysis does not attempt to break down or analyze the complex regulatory barriers that currently hinder interregional transmission planning in the United States. Issues such as cost allocation disputes, state and regional jurisdictional fragmentation, lack of centralized transmission siting authority, and limitations in current FERC regulations are critical factors influencing the feasibility and implementation of large-scale offshore and interregional transmission projects. However, these regulatory and institutional dimensions fall outside the scope of this study, which focuses primarily on technical, economic, and planning aspects. As

such, the findings should be understood as technically based results that will require iterative conversations and modeling repetitions based on stakeholder conversations to incorporate regulatory and political hurdles that were not accounted for in this comparison.

Future research that builds on this study comparison and place study results in the context of the developing offshore wind landscape can further enhance transmission planning discussions and clarity around deployment. Further research is needed for barriers and pathways towards raising the single source contingency limit in the East, as recommended by both studies, and adopting remedial action schemes to limit major grid interruption. While each study considered space use considerations, specific siting analysis for exact points of interconnection, beach landings, and transmission corridors could be useful for continuing conversations among stakeholders (especially for points of interconnection identified in both studies). Future work exploring cost allocation barriers and mechanisms for offshore transmission between regions could build on the cost evaluations and economic outcomes outlined in this thesis. State and regional coordination processes, like the Northeast States Collaborative, have been exploring regulatory and policy avenues for interregional transmission and additional work is needed to explore coordination frameworks to this effect. A key shared outcome was that technology standardization (cables, offshore platforms and converter stations, etc) is essential for a successfully coordinated offshore grid. Further research is needed into standardization through regulations, policy, and effective coordination between projects and regions including considering a similar model to the TenneT 2 GW standard. transmission planning outcomes for offshore wind outcomes from these studies may require adjustments in study assumptions and additional analyses. Finally, these studies could be impacted by recent withdrawal of federal support for offshore wind and will require future research. For example, the AOSWTS includes

some federal incentives for offshore wind (and other clean energy generation) in economic and capacity expansion modeling which means study outputs may be affected by a decrease in these incentives.

## 5.2 Conclusion

Since the administration change in January 2025, a number of federal actions have created uncertainty for the offshore wind industry including halting already approved projects, withdrawing future lease areas, removing or reducing tax incentives for offshore wind, and rescinding funding for port and transmission investments that support lease area development (Howe & Feinberg, 2025; Sommer, 2025). While legal responses from developers and states have resulted in a string of court cases where judges have granted numerous injunctions against work freezes for already approved offshore wind projects, these actions continue to create uncertainty for the industry and transmission planning for future interconnection (Kranz, 2025; Moon, 2025). As developers, state agencies, regulatory bodies, transmission operators, and other stakeholders navigate this landscape there has been pushback on these actions. State leadership and transmission operators have emphasized that the attempted rescission of permits for already approved projects (including those that are close to completion) jeopardizes jobs, ratepayers, and especially grid reliability. A joint statement from governors of Connecticut, Massachusetts, New York, and Rhode Island warned the moves would increase ratepayer costs and harm energy independence (*Joint Statement on Offshore Wind*, 2025). ISO New England has stated that offshore wind is an integral part of near-term and future modeling to supply reliable electricity for New England and these actions will threaten grid reliability and increase costs (Mannion, 2025).

Amid uncertainty at the federal level, there is an increased importance for organized action at the state and regional level towards coordinated offshore transmission. Further, the results of this thesis highlight that not only is coordination necessary, but it also can create both economic and grid reliability benefits for each region. A well-planned and coordinated deployment of transmission for offshore wind can be leveraged to build interregional transmission that enables resource sharing, reduces the need for duplicative generation investments, and strengthens grid resilience and reliability. The comparison of these two first of their kind studies highlight future actions that build upon existing work and creates an understanding of separate frameworks through which planners and other stakeholders can consider development pathways. Shared findings (such as increasing single source contingency limits, standardizing transmission technologies, and onshore transmission upgrades) and differences in findings (such as in siting and permitting constraints, capacity and location of POIs and transmission corridors, and power flow modeling) can be used in iterative responsive analysis processes between transmission planners and decision-makers about power systems decisions. The comparison of study processes and tools in this thesis can contribute to broader understanding of the future implications of decisions made today and help enable productive and responsive discussions to enable coordinated interregional transmission development for a reliable and decarbonized future grid.

## Appendix A

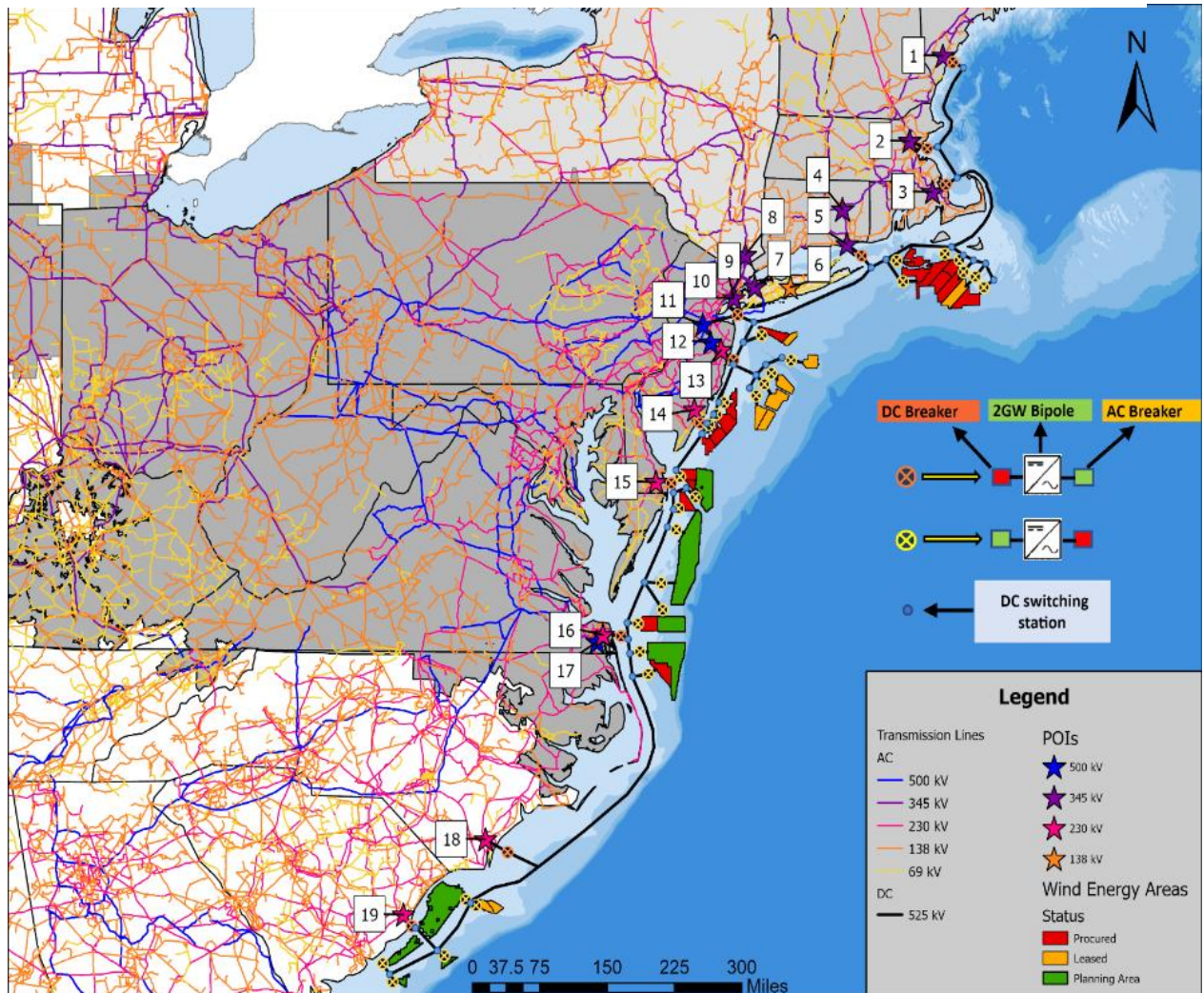
**Table 5.** Key study model comparison

	Model	Granularity	Objective	Model Type	Operating Conditions	Inputs	Outputs	Contingency	Results
OSPRE	Model 1	90,059-bus (Eastern Interconnection)	Evaluate cost of expanding the grid at specific POI locations Choose lowest expansion cost POIs	Iterative DC power flow Transmission Adequacy & Reliability Assessment (TARA) Points of Interconnection Assessment (POIA)	Single loading condition: Summer Peak 2031	Onshore transmission expansion costs both AC and DC (transmission lines, substation expansion, power transformers, converter stations) Candidate POIs and OSW amount	Iterative selection of POIs with capacities to minimize onshore investment costs Cost per MW upgrade at each POI (\$/MW)	N-1	Selected POIs, capacities, and cost per MW expansion for 33GW and 76GW of OSW
	Model 2	843-bus (Eastern Interconnection)	Optimize transmission and generation investments to minimize total investment and operation costs over planning period. Meeting 90% grid decarbonization and 115% of annual peak energy use	Coordinated expansion planner (CEP): Reduced bus DC power flow, coordinating transmission and generation investments	2031-2051 17 operating blocks per year	Load data: projected to 2031 Cost data: AC transmission line, onshore transformers, reach circuit transmission, offshore transmission Renewable energy data Network data: reduced bus network Offshore Grid Template (OSGT)	Selection of offshore grid line capacities, onshore transmission and generation expansions, and associated total investment amount as a function of OSW amount (100-600 GW)	No Identifies OSGT that could be expanded to plan for future contingency planning	250 GW OSW minimizes transmission investments At lower OSW levels, onshore transmission necessary to access onshore renewable energy and relieve congestion
	Model 3	169-bus (Nationwide)	Asses economic benefits of a national macrogrid for connecting an Atlantic offshore wind transmission backbone with broader US grid	Coordinated Generation and Transmission Expansion Planning	2024-2051 19 blocks per year	OSW profiles: NREL Wind Toolkit HVDC Macrogrid topology OSW amount (constraint)	Selection of onshore equal capacity and offshore HVDC lines	N-1 (National scale equal capacity parallel lines)	Macrogrid reduces East Coast AC transmission expansion and costs (from non-Macrogrid) by \$45B between 85-200 GW Alleviates congestion in AC transmission grid
DOE	AC Power Flow and Contingency (Steady State)	92,000 Eastern Interconnection	Monitor grid performance under steady-state and contingency scenarios based on voltage limits, branch	Multiregional Modeling Working Group (MMWG) model+ Offshore Wind Integration Tool	2030 and 2050 Summer peak, winter peak, spring off peak	Network topologies from adapted MMWG planning cases with OSW integration	Analysis of grid operation under different contingencies for 230kV and above for 2030 and 2050	N-0, N-1, N-2	N-0: no overloads or voltage limit violations in 4 regions N-1/N-2: Various violations
	Grid Strength (Steady State)	92,000 Eastern Interconnection	Screen POI candidates for 30 GW scenario based on system strength	MMWG+Automated System Wide Strength Evaluation Tool	2030 30 GW, summer peak, winter peak	24 selected POIs in 2030	Classification of POIs as 'strong', 'moderate', 'weak' based on short-circuit ratios	N-0, N-1, N-2	Contingencies have major impact on the grid strength 9 'strong', 3 'moderate', 12 'weak'
	Dynamic Performance	92,000 Eastern Interconnection (ISO-NE focused)	Understand grid performance under cascading outages	MMWG+ Dynamic Contingency Analysis Tool	2030 30 Gw Summer peak, winter peak	Network topologies from adapted MMWG planning cases with OSW integration	Evaluation of frequency errors and system stability following cascading outages	Dynamic contingency	Results for 6 345 kV circuit contingencies and associated voltage profiles post-contingency

*Note.* Created by author

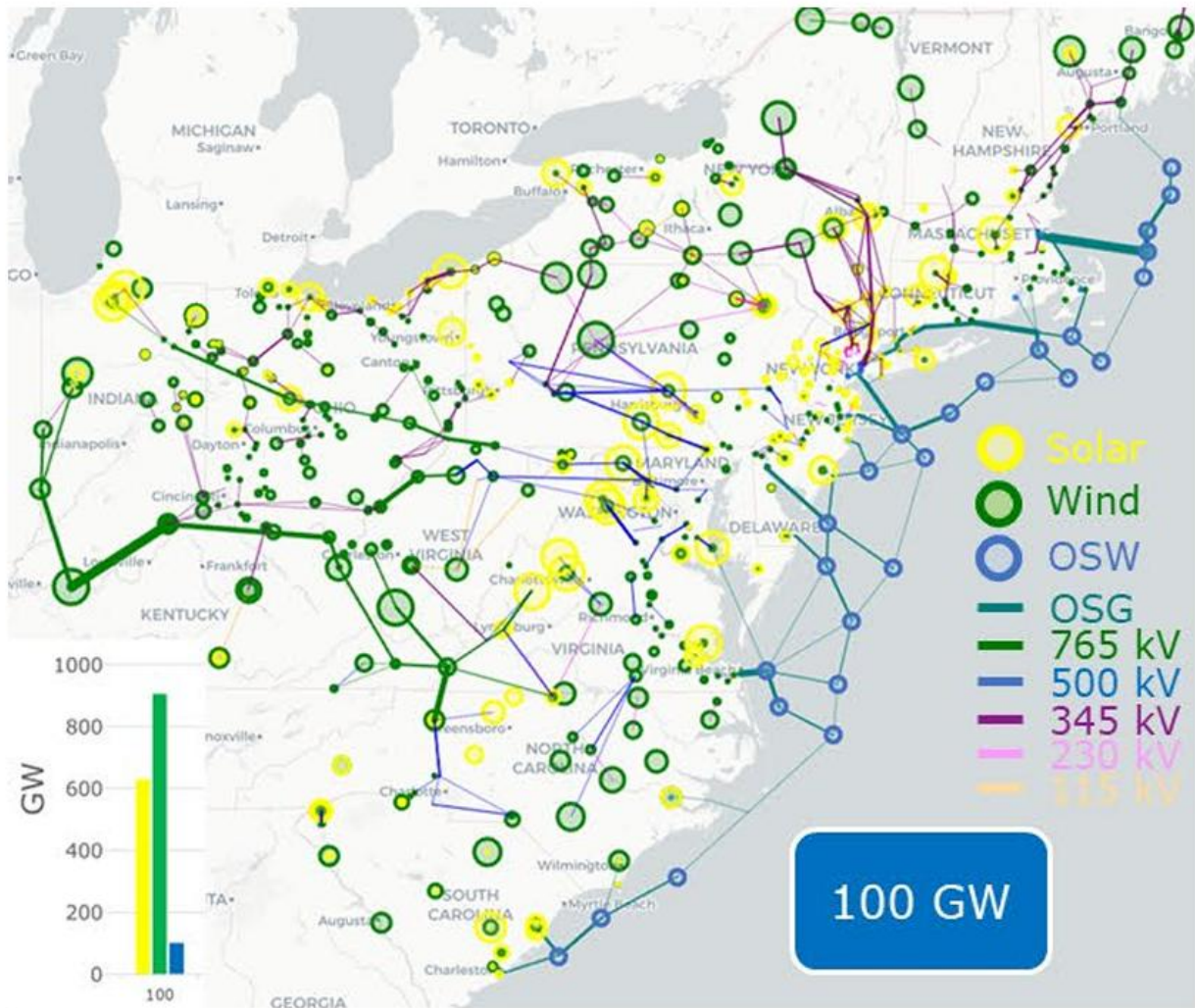
## Appendix B

**Figure 9.** OSPRE Model 1 Topology for 85 GW



*Note.* From Offshore Wind Transmission Expansion Planning for the U.S. Atlantic Coast. Hines et al, 2025, page 92 (<https://tufts.app.box.com/v/osw-ospre-2025-01-v11-trans>). Reprinted with permission.

**Figure 10.** OSPRE Model 2 Topology for 100 GW

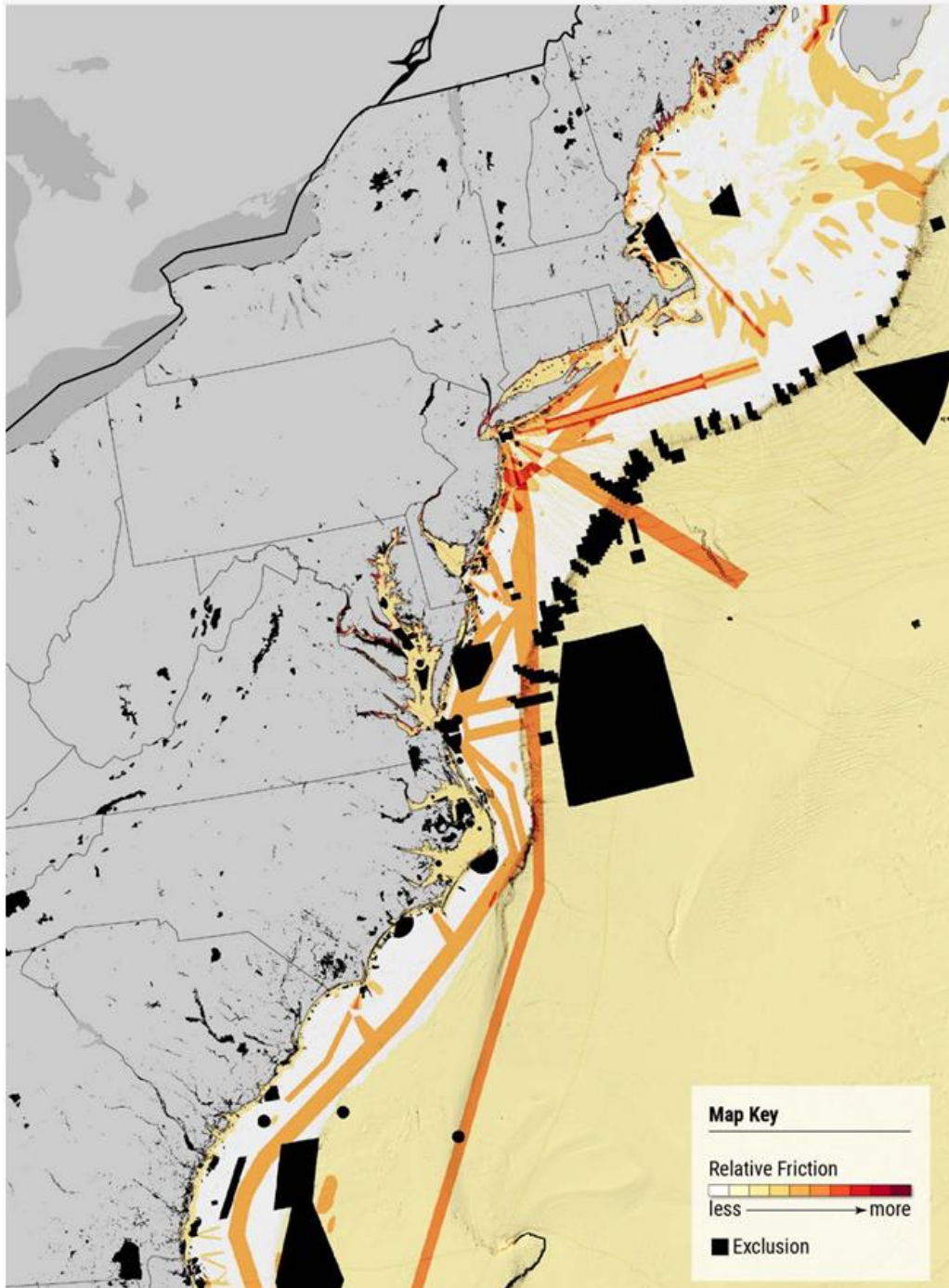


*Note.* From Offshore Wind Transmission Expansion Planning for the U.S. Atlantic Coast. Hines et al, 2025, page 53 (<https://tufts.app.box.com/v/osw-ospre-2025-01-v11-trans>). Reprinted with permission.

## Appendix C

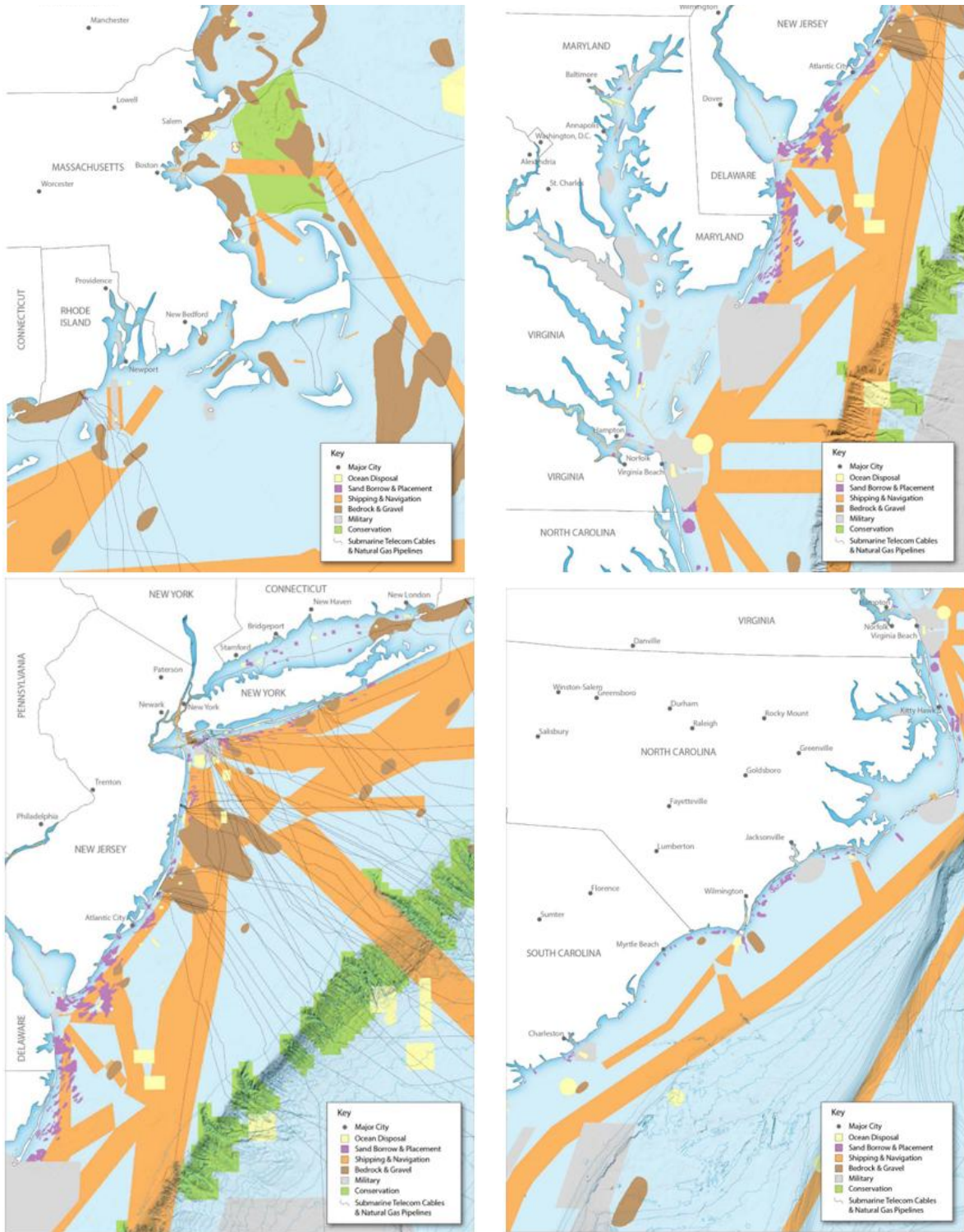
Figures 11 and 12 are the results from the AOSWTS spatial analysis, with Figure 11 showing exclusion areas and frictions for the East Coast and Figure 12 depicting spatial uses by region.

**Figure 11.** Exclusion areas and frictions for East Coast from DOE study.



*Note.* From Atlantic Offshore Wind Transmission Study. Brinkman et al, 2024, page 29 (<https://research-hub.nrel.gov/en/publications/atlantic-offshore-wind-transmission-study-us-department-of-energy>). In the public domain.

**Figure 12.** Siting constraints by region in AOSWT study.



*Note.* From Atlantic Offshore Wind Transmission Study. Brinkman et al, 2024, page 25-28 (<https://research-hub.nrel.gov/en/publications/atlantic-offshore-wind-transmission-study-us-department-of-energy>). In the public domain.

## Appendix D

**Table 6.** Space-use layers used in DOE siting considerations

Type	Sources
<b>Seafloor Geology</b>	
Water Depth	General Bathymetric Chart of the Oceans (British Oceanographic Data Centre 2022)
Underwater Slope	calculated
Seafloor Sediment	US Geo Survey (1985)
<b>Conservation</b>	
Marine national monuments	NOAA (2021a; 2021b) MPA inventory
National marine sanctuaries	NOAA (2021a; 2021b) MPA inventory
Atlantic canyons	NOAA (2021c) Atlantic cadastral data
Artificial reefs	NOAA (2021c) National Marine Fisheries Service
<b>Regulatory</b>	
OSW planning areas	BOEM-NOAA (2021 Marine Cadastre)
OSW energy leases	BOEM-NOAA (2021) Marine Cadastre
OCS and resources	BOEM (2022) Marine mineral Information system
OCS sand and gravel borrow areas	BOEM (2022) marine minerals information system
USACE South Atlantic Division sand sources/borrow areas	USACE (2022a)
USACE borrow areas	USACE (2022b)
USACE placement areas	USACE (2022b)
Danger zones and restricted areas	BOEM-NOAA (2021) Marine Cadastre
Ocean disposal sites	US EPA (2023)
<b>Shipping and navigation</b>	
Shipping lanes	BOEM-NOAA (2021) Marine cadastre
National federal channel framework	USACE (2022c)
Shipping safety fairway	Stone (2022)
Fairway anchorages	Stone (2022)
<b>Physical Structures</b>	
NG pipelines	Homeland infrastructure foundation -level data (2021)
Submarine cable areas	BOEM-NOAA (2021) Marine Cadastre
Military ship shock boxes	BOEM-NOAA (2021) Marine cadastre
Unexploded ordnance locations	BOEM-NOAA (2021) Marine cadastre
Automated wrech and obstruction information systems	NOAA (2021d)
Atlantic shipwrecks database (conf.)	BOEM (personal communication in 2022)

*Note.* Data sources used in AOSWTS modeling. Adapted from Atlantic Offshore Wind Transmission Study. Brinkman et al, 2024, page 20-24 (<https://research-hub.nrel.gov/en/publications/atlantic-offshore-wind-transmission-study-us-department-of-energy>). In the public domain.

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