Learning from the Experts Webinar Series

New York State and Regional Transmission Planning

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March 30,2022

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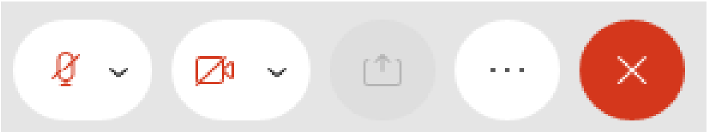

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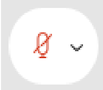
You'll see  **when your microphone is muted**

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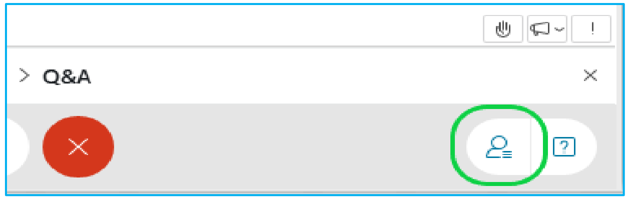

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Learning from the Experts

This webinar series is hosted by NYSERDA's offshore wind team and features experts in offshore wind technologies, development practices, and related research.

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

New York State and Regional Transmission Planning for Offshore Wind Generation

PRESENTED BY

Johannes Pfeifenberger

PRESENTED AT

NYSERDA Offshore Wind Webinar

MARCH 30, 2022

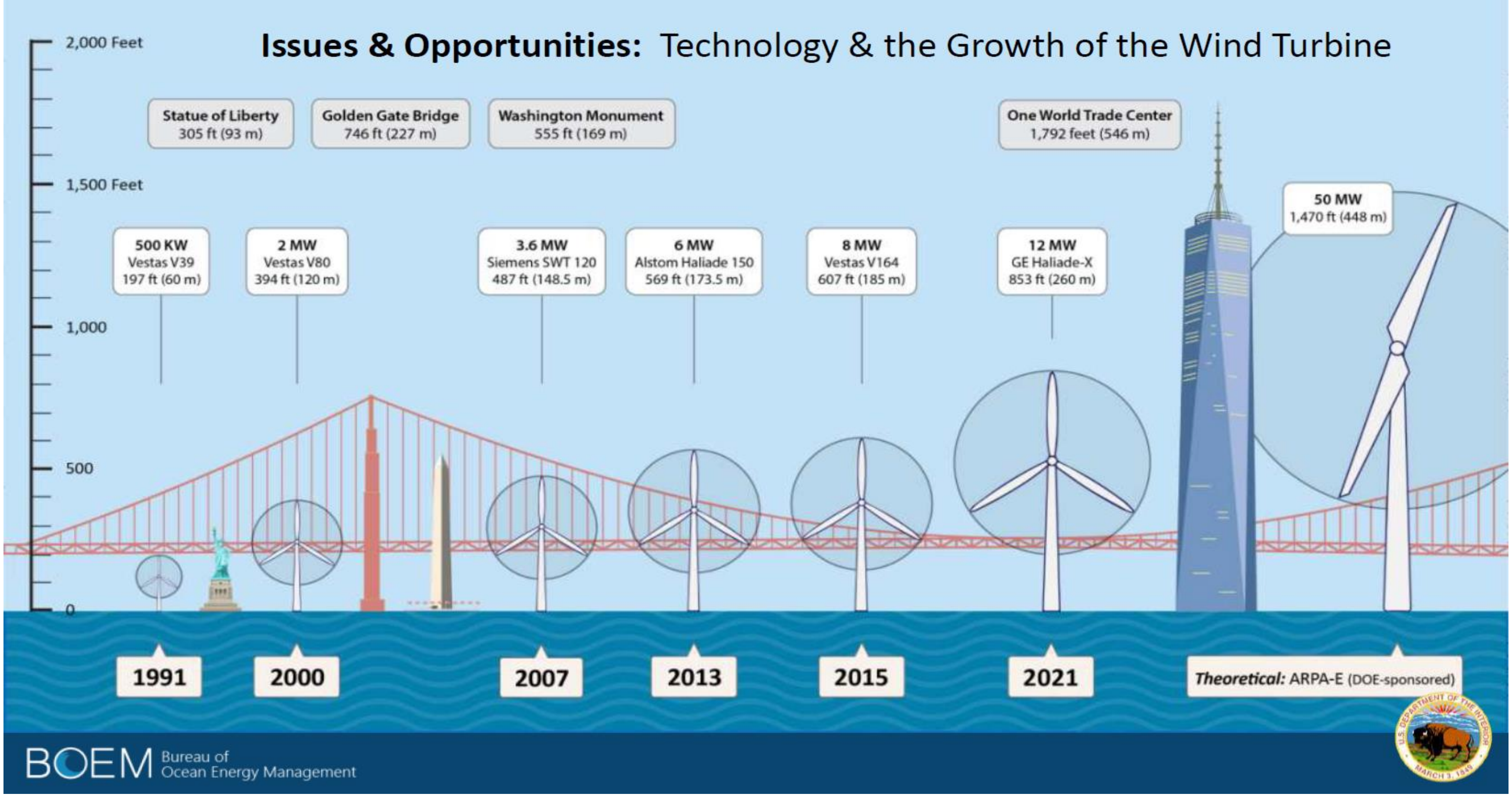
Brattle

Contents

Background on Transmission Planning

- U.S. Offshore Wind Generation Trends
- US Transmission Investment
- Current Planning Processes
- Barriers to Interregional Transmission
- Recommendations for 21st Century Transmission Planning
- New York OSW Transmission Planning Context

Major Technological Advances = Reduced Cost of OSW Generation



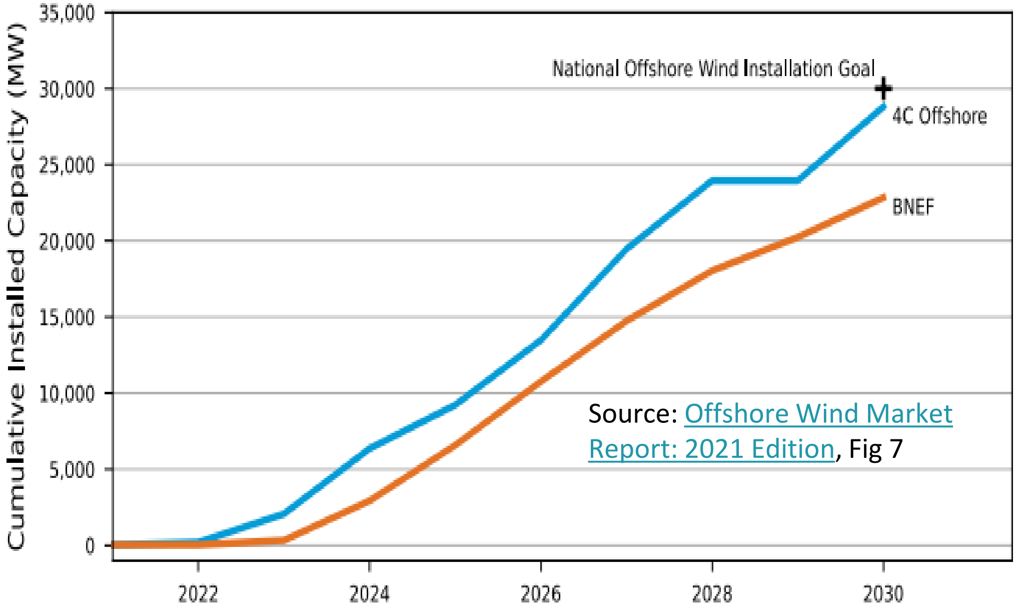
Substantial OSW Generation Planned and Needed

Thousands of MW of new clean resources will need to be built to achieve state decarbonization goals—including substantial offshore wind beyond the **30,000 MW** of current commitments in eastern U.S.

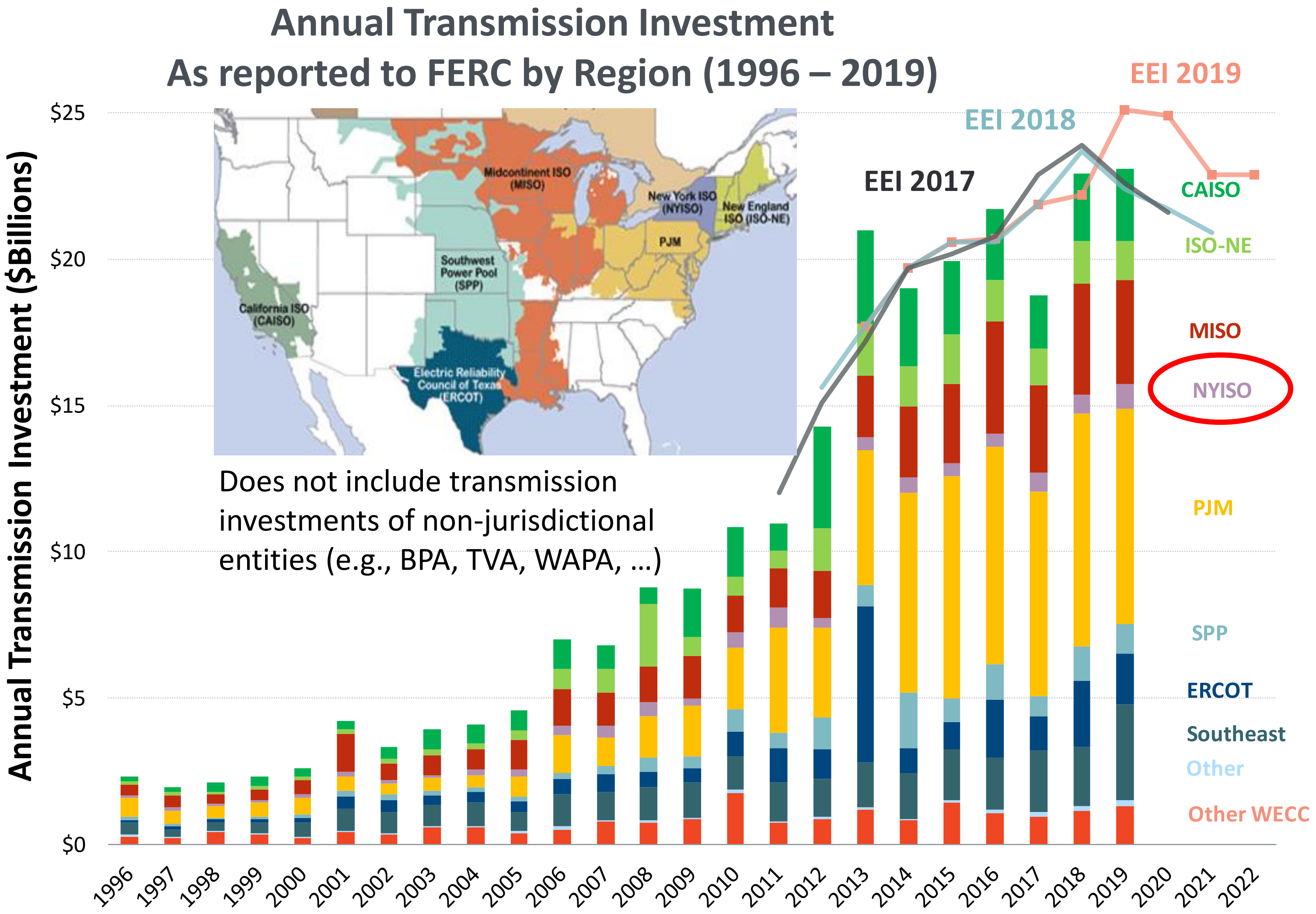
A key challenge: **ensuring a pathway low-cost, low-impact solutions** for delivering offshore wind energy to onshore grid and population centers

Region	Already Contracted	Total Committed	Potentially Needed
New England	3,120 MW	5,900 MW	25-40,000 MW by 2050
New York	4,316 MW	9,000 MW	10-25,000 MW by 2040
Mid-Atlantic	4,129 MW	13,900 MW	

Sources: **Contracted and committed**: ACP_FactSheet-Offshore_Final (cleanpower.org), 2021. **Potentially needed**: Brattle Study of NE by Jurgen Weiss and Michael Hagerty, "Ach`ieving 80% GHG Reduction in New England by 2050," September 2019. Brattle Study for NYISO by Roger Lueken et al., "New York's Evolution to a Zero Emission Power System: Modeling Operations and Investment Through 2040." May 18, 2020. E3, "Electric Reliability under Deep Decarbonization in New England," August 4, 2020. E3, "Pathways to Deep Decarbonization in New York State," June 24, 2020. https://www.nyserda.ny.gov/All-Programs/Programs/Offshore-Wind/Focus-Areas/NY-Offshore-Wind-Projects. Initial Report on New York Power Grid Study, January 19, 2021.



Transmission Investment is at Historically High Levels

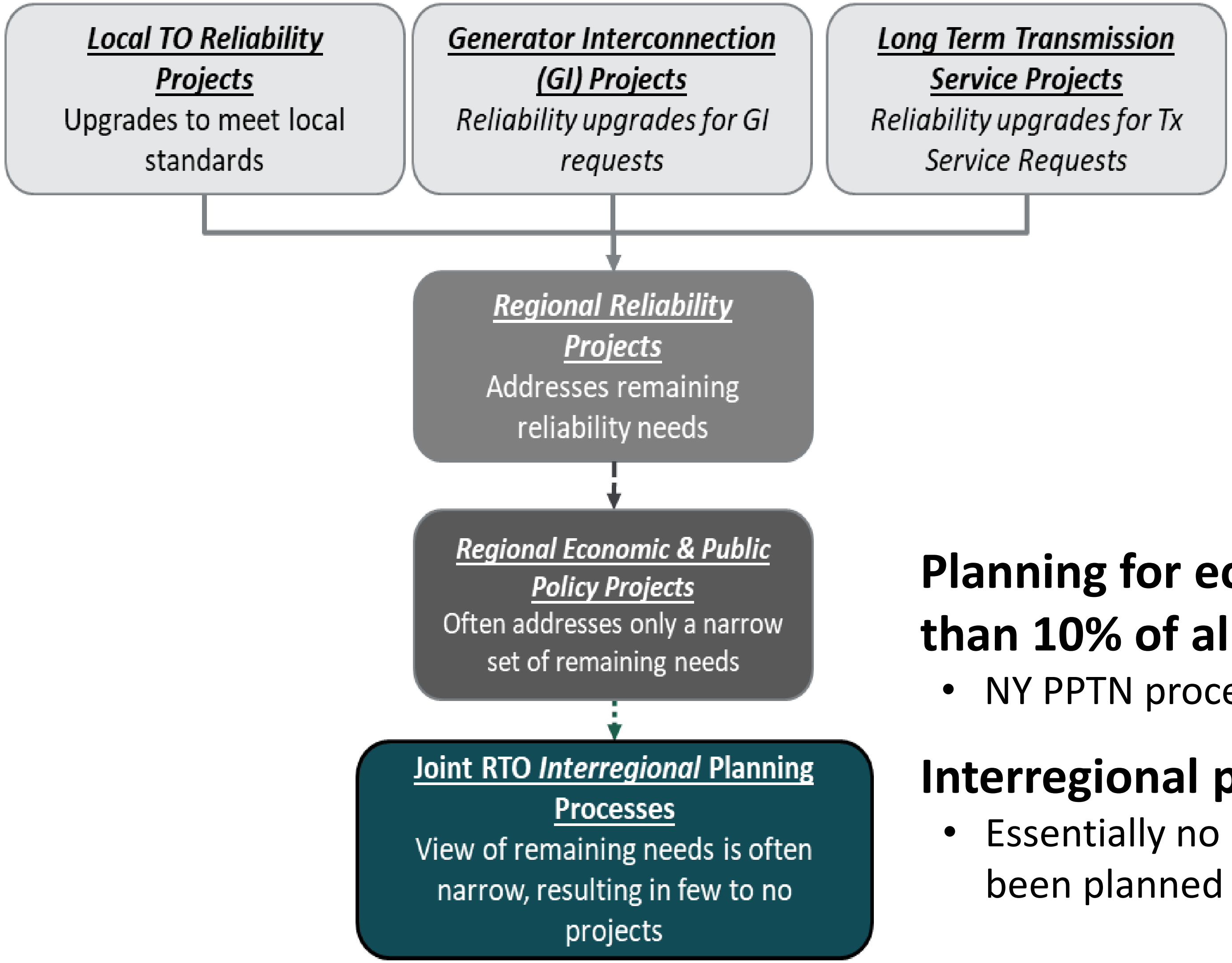


Source: FERC Form 1 Data, EEI "Historical and Projected Transmission Investment" most recent accessed here: https://www.eei.org/resourcesandmedia/Documents/Historical%20and%20Projected%20Transmission%20Investment.pdf

$20-25 billion in annual U.S. transmission investment, but:

- More than 90% of it justified solely based on reliability needs without benefit-cost analysis
  - About 50% solely based on “local” utility criteria (without going through regional planning processes)
  - The rest justified by regional reliability and generation interconnection needs
- While significant experience with transmission benefit-cost analyses exists, very few projects are justified based on economics and overall cost savings

Current U.S. Grid Planning Processes are Siloed



These solely reliability-driven processes account for > 90% of all transmission investments

- None involve any assessments of economic benefits (i.e., cost savings offered by the new transmission)
- Which also means these investments are not made with the objective to find the most cost-effective solutions
- Will yield higher system-wide costs and electricity rates

Planning for economic and public-policy projects: less than 10% of all transmission investments

- NY PPTN process: one of a few well-working exceptions

Interregional planning processes are large ineffective

- Essentially no major interregional transmission projects have been planned and built in the last decade

Barriers to Interregional Transmission Planning & Development

A. Leadership, Alignment and Understanding	1. Insufficient leadership from RTOs and federal & state policy makers to prioritize interregional planning 2. Limited trust amongst states, RTOs, utilities, & customers 3. Limited understanding of transmission issues, benefits & proposed solutions 4. Misaligned interests of RTOs, TOs, generators & policymakers 5. States prioritize local interests, such as development of in-state renewables
B. Planning Process and Analytics	**6. Benefit analyses are too narrow, and often not consistent between regions** 7. Lack of proactive planning for a full range of future scenarios **8. Sequencing of local, regional, and interregional planning** 9. Cost allocation (too contentious or overly formulaic)
C. Regulatory Constraints	10. Overly-prescriptive tariffs and joint operating agreements 11. State need certification, permitting, and siting

Source: Appendix A of A Roadmap to Improved Interregional Transmission Planning, November 30, 2021. Based on interviews with 18 organizations representing state and federal policy makers, state and federal regulators, transmission planners, transmission developers, industry groups, environmental groups, and large customers.

Proposal: Transmission Planning for the 21st Century*

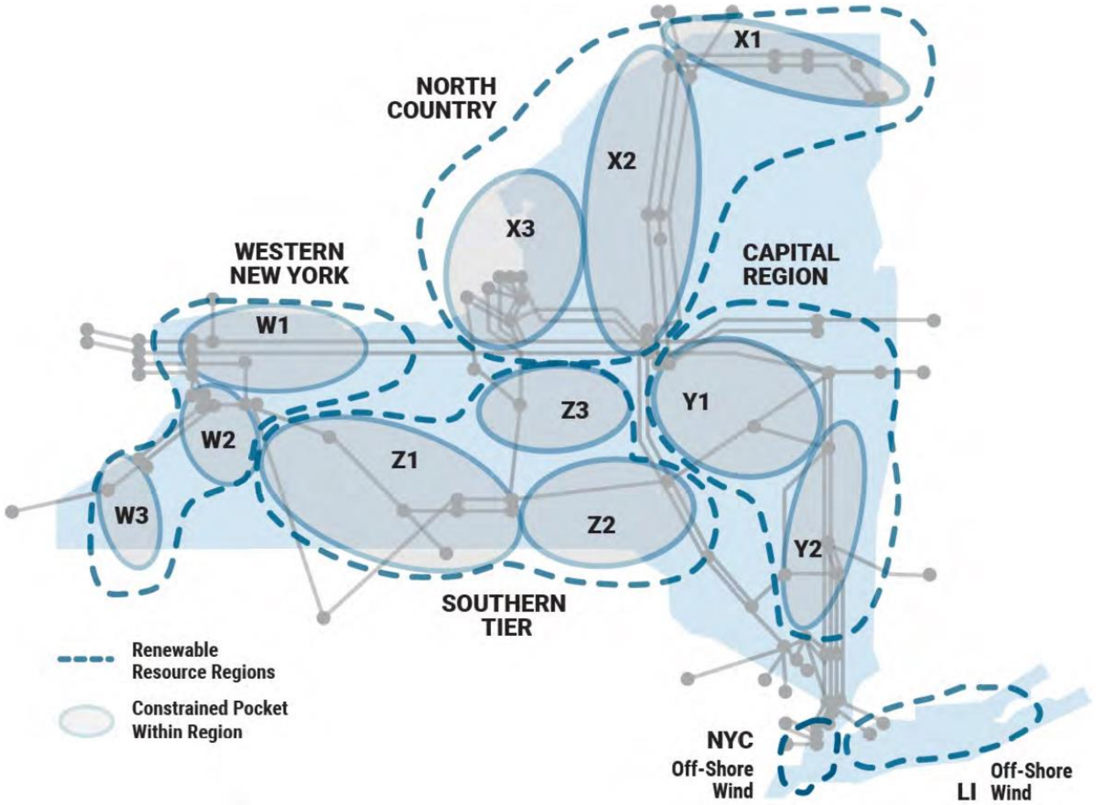
Available experience points to <u>proven planning practices</u> that reduce total system costs and risks:

1. **<u>Proactively plan</u> for future generation and load** by incorporating realistic projections of the anticipated generation mix, public policy mandates, load levels, and load profiles over the lifespan of the transmission investment
2. **Account for the <u>full range of transmission projects' benefits</u>** and **<u>use multi-value planning</u>** to comprehensively identify investments that cost-effectively address all categories of needs and benefits
3. **Address uncertainties and high-stress grid conditions explicitly through <u>scenario-based planning</u>** that takes into account a broad range of plausible long-term futures as well as real-world system conditions, including challenging and extreme events
4. **Use comprehensive transmission <u>network portfolios</u>** to address system needs and **<u>cost allocation</u>** more efficiently and less contentiously than a project-by-project approach
5. **Jointly <u>plan inter-regionally</u> across neighboring systems** to recognize regional interdependence, increase system resilience, and take full advantage of interregional scale economics and geographic diversification benefits

* Brattle & Grid Strategies Report: Transmission Planning for the 21st Century: Proven Practices that Increase Value and Reduce Costs, October 2021.

New York Power Grid Study and Meshed Offshore Grid Study

PSC and NYSERDA completed the initial report on NEW YORK POWER GRID STUDY (PGS), which consists of 3 proactive components:



See: Full PGS Report and Summary Presentation

9000+ MW OSW

- Utility Study: local transmission and distribution (LT&D) needs; advanced grid technologies
- Offshore Wind (OSW) Study: bulk transmission study to integrate 9,000 MW of offshore wind
- Zero Emissions Study: bulk transmission, generation, and storage needed to achieve 70% renewable generation by 2030 and a zero emissions grid by 2040

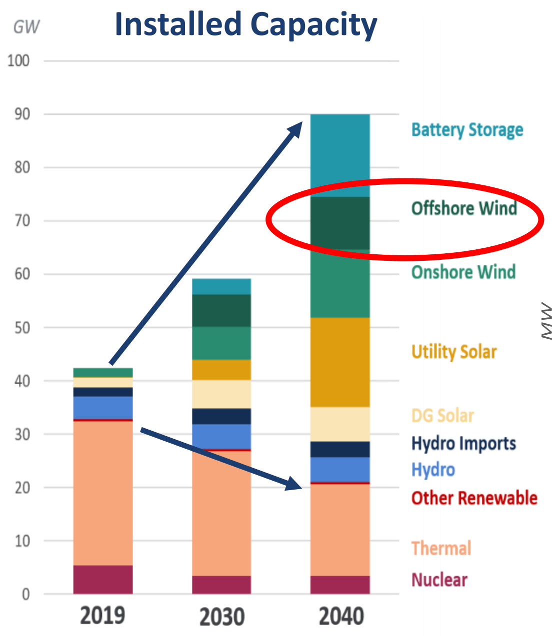
Building on the PGS, NYSERDA commissioned an evaluation of the options for and benefits of creating a MESHED OFFSHORE GRID

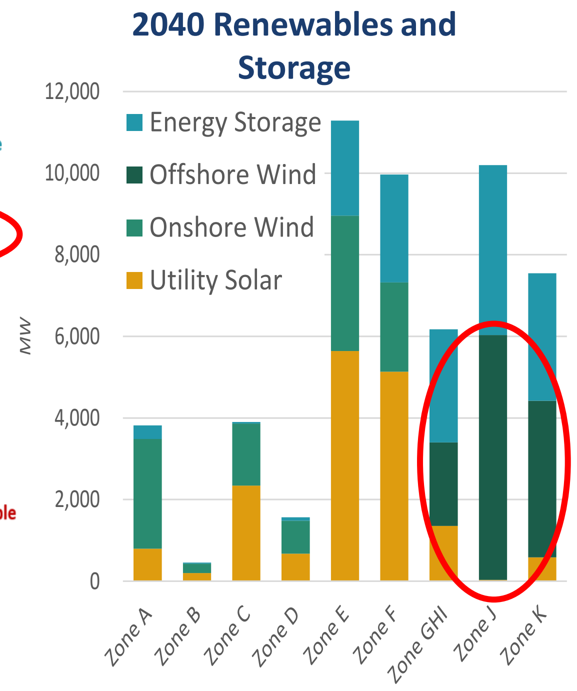
New York PGS: Substantial Renewable Generation and Storage Needs

Analyzed transmission, generation, and storage needed to meet NY’s goals of zero-emission electricity by 2040 and 70% renewable generation by 2030 (drawing on New York Decarbonization Pathways Study)

2040 Results:

- Installed capacity more than double today’s
- **10-15 GW each: onshore wind, offshore wind, solar, and storage**
- Ideally developed in certain areas:
  - Onshore wind primarily in western and northern NY (NYISO Zones A-F)
  - Offshore wind downstate (I, J, K)
  - Solar in central NY
  - Storage in central and downstate NY
- 17 GW of “thermal” backup generation fueled by renewable natural gas (as placeholder for future technologies)



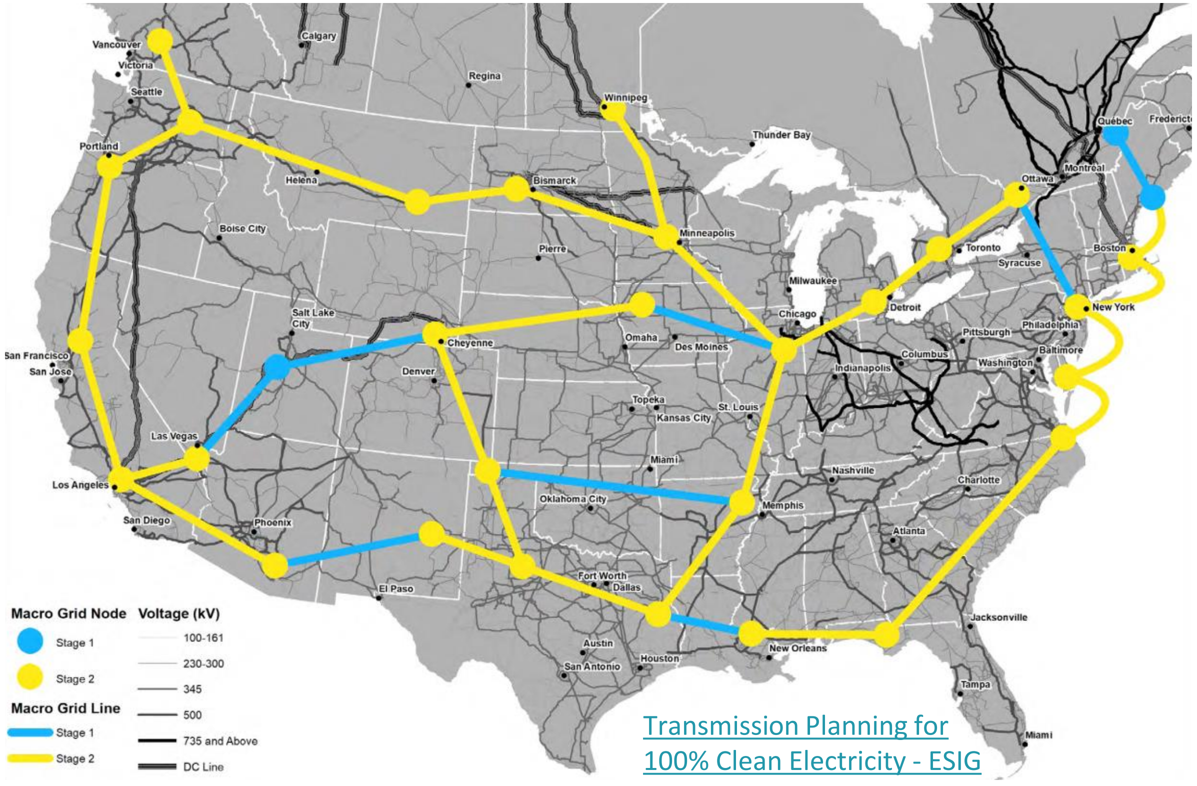


- **By 2040, congestion and curtailments point to the potential need for cost-effective bulk transmission upgrades into downstate, NYC, and Long Island … with new PPTN already under way**

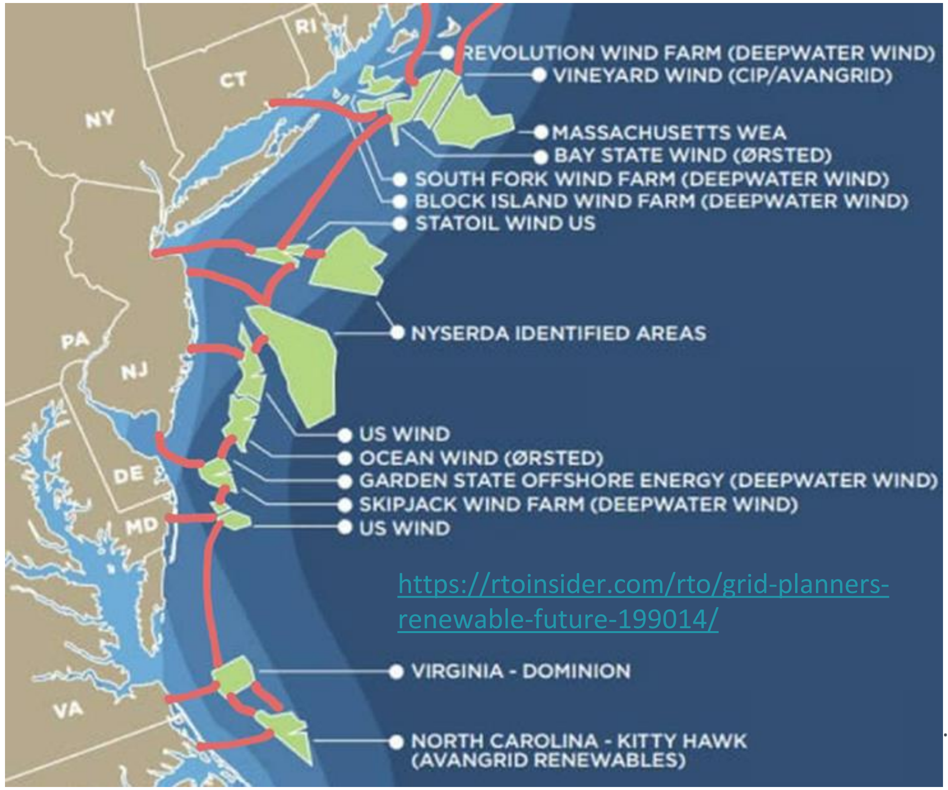
Long-term: OSW generation integrated into a more geographically-diverse national grid?

As state and regional shares of renewable generation increase, a robust inter-regional grid will become critical to ensure reliability and cost effectiveness

- The geographic scale of the grid needs to (1) reach well beyond the size of large weather systems; and (2) integrate a diverse mix of resources (wind, solar, hydro, …)
- Local storage and distributed resources will help, but not eliminate the need for broad geographic diversification of uncertain intermittent generation



Transmission Planning for 100% Clean Electricity - ESIG



https://rtoinsider.com/rto/grid-planners-renewable-future-199014/

Interregional Transmission Planning for Offshore Wind

Atlantic Offshore Wind Transmission Study (AOWTS), a 2-year study effort led by NREL to:

- Evaluate multiple pathways to offshore wind goals through coordinated transmission solutions along the U.S. Atlantic Coast
- Both near-term (by 2030) and long-term (by 2050)
- For various scenarios of electricity supply and demand
- Considering: transmission needs, available technologies, system-wide cost impacts, grid reliability, resilience, and ocean co-use

TASK 1
Offshore Wind Data Collection, Modeling Framework, and Formation of Technical Review Committee

TASK 2
Transmission Expansion Planning
Envision future grids

TASK 3
Production Cost and Resource Adequacy
Simulate operability

TASK 4
Technology Characterization
Evaluate cost, performance, and siting

TASK 5
Reliability and Offshore Grid
Evaluate reliability of the grid by studying contingency analyses

TASK 6
Resilience and Extreme Weather
Evaluate grid operation during cascading events due to extreme weather

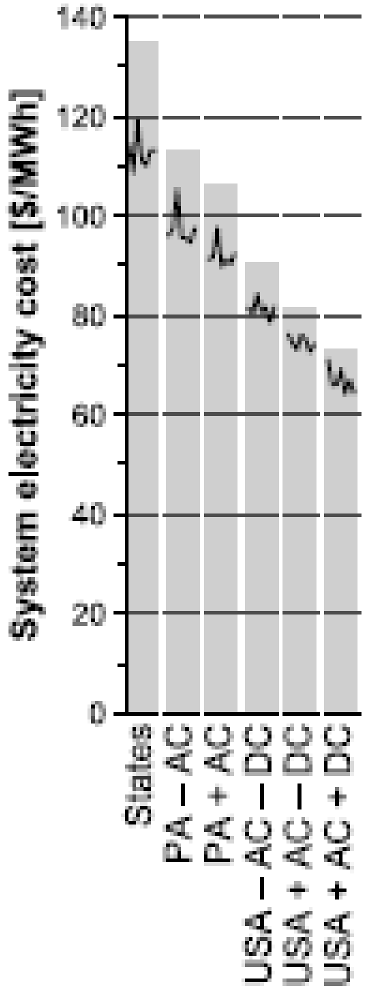
TASK 7
Review by Technical Review Committee and Final Report

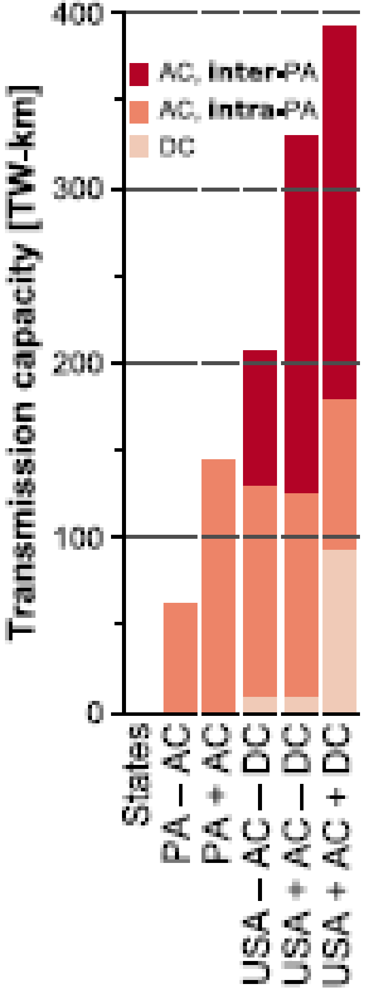
National Studies Show Large Benefit of Interregional Transmission

Study	Region	Findings
NREL North American Renewable Integration Study (2021)	U.S., Canada, Mexico	• Increasing trade between countries can provide $10-30 billion in net benefits • **Interregional transmission expansion achieves up to $180 billion in net benefits**
MIT Value of Interregional Coordination (2021)	Nation-Wide	• National coordination of **reduces the cost of decarbonizing by almost 50% compared to no coordination between states** • The lowest-cost scenario builds almost 400 TW-km of transmission; including **roughly 100 TW-km of DC capacity between the interconnections** and over 200 TW-km of interregional AC capacity • **No individual state is better off implementing decarbonization alone** compared to national coordination of generation and transmission investment • Low storage and solar costs still result in significant cost effective interregional transmission
Princeton Net Zero America Study (2021)	Nation-Wide	• Achieving net-zero emissions by 2050 requires **700-1,400 TW-km of new transmission** • Investment in transmission needed ranges **$2-4 trillion dollars by 2050**
U.C. Berkeley 90% by 2035 (2020)	Nation-Wide	• The only national study that suggest relatively little interregional transmission would be needed to achieve 90% clean electricity. However, the study's simulation approach does not utilize more granular and well-established methods to properly value interregional transmission.
Vibrant Clean Energy Interconnection Study (2020)	Eastern Interconnect	• **40 to 90 TW-km of transmission is built by 2050** to meet climate goals • Transmission development can create **1-2 million jobs in the coming decades**, more than wind, storage, or distributed solar development • Transmission **reduces electricity bills by $60-90 per MWh**
Wind Energy Foundation Study (2018)	ERCOT, MISO, PJM, and SPP	• Transmission planners are not incorporating this rising tide of voluntary corporate renewable energy demand into plans to build new transmission
NREL Seams Study (2017)	Eastern and Western Interconnects	• Major new ties between interconnections **saves $4.5-$29 billion** over a 35 year period

Source: A Roadmap to Improved Interregional Transmission Planning, November 30, 2021.

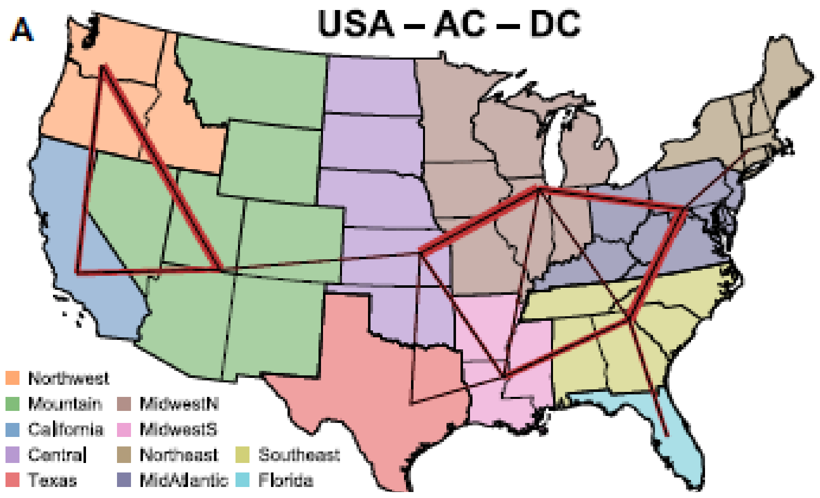
Example: MIT Value of Interregional Coordination (2021)



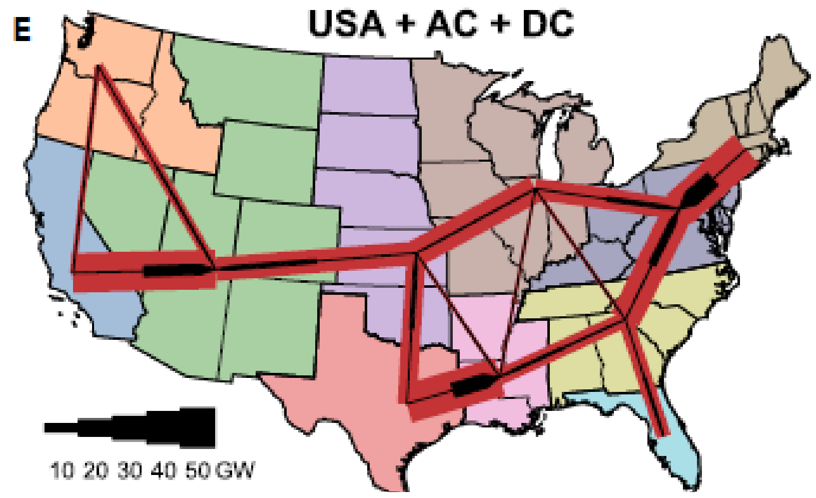


Key Result: A more robust national grid would significantly reduce the total cost of decarbonizing the grid … but (higher-cost) regional and more local solutions may also be feasible

Optimal Transmission Build
With and Without National Transmission Coordination



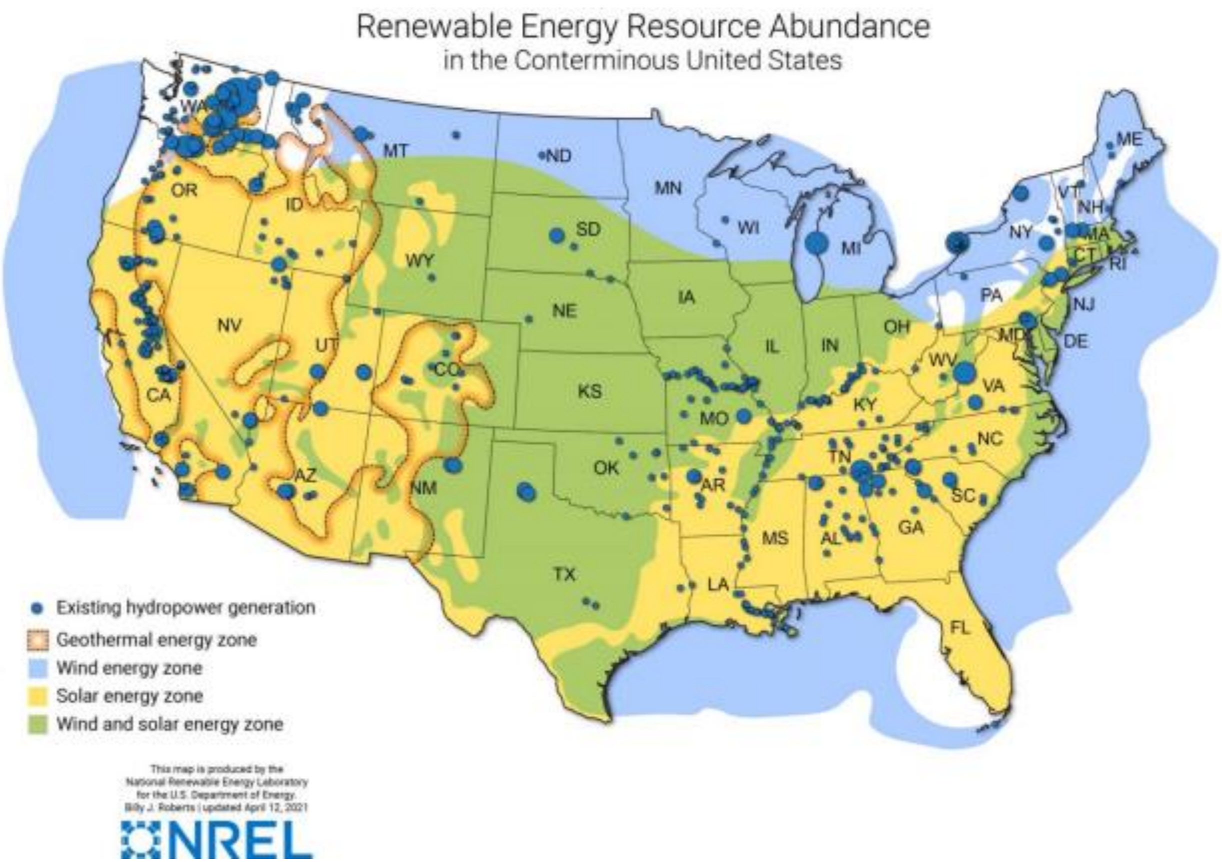
Regional Only
(20% more expensive)



Regional + Interregional

DOE’s new National Transmission Planning (NTP) Study

In support of the Infrastructure Investment and Jobs Act, DOE’s Office of Electricity launched the Building a Better Grid Initiative to catalyze the nationwide development of new and upgraded high-capacity electric transmission lines.



As one of the first steps to support this initiative, DOE is conducting the National Transmission Planning Study in partnership with the PNNL and NREL to:

- Identify transmission that will provide broad-scale benefits to electric customers
- Inform regional and interregional transmission planning processes
- Identify interregional and national strategies to accelerate decarbonization while maintaining system reliability

Builds on DOE, NREL, PNNL expertise and recent studies (see study overview, slides 54-79)

Caution: Limitations of National Studies also Apply to Planning for OSW

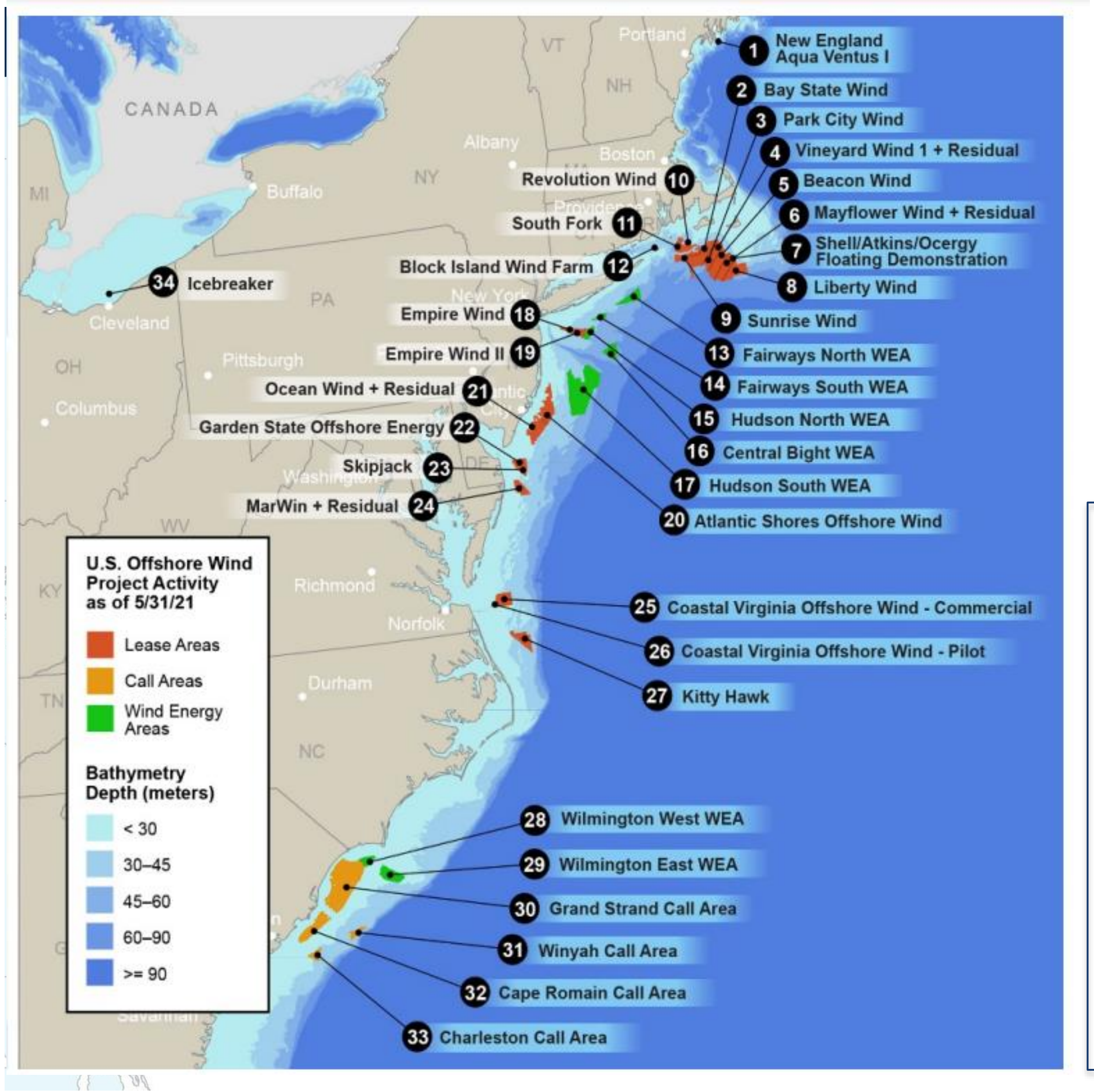
Although existing studies demonstrate the benefits of interregional transmission, they have not successful in motivating improved interregional planning or actual transmission project developments. The reasons include some or all of the following:

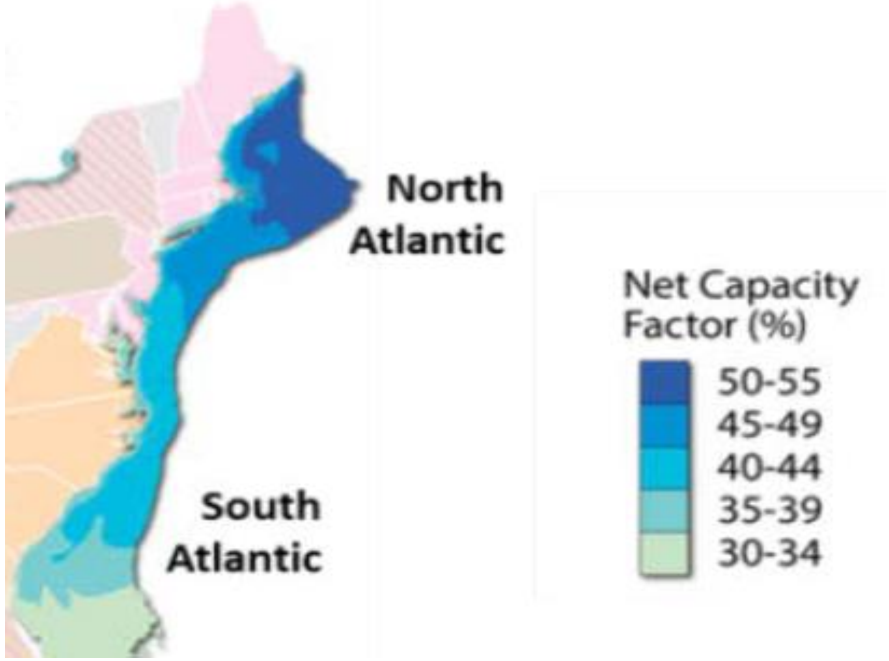
- Many studies **tend to analyze aspirational clean energy targets (e.g., 90% by 2035 or 100% by 2050)** not the actual policies and mandates applicable for the next 10-15 years
  - By not modeling actual state or federal policies, clean-energy mandates, and renewable technology preferences, the studies cannot demonstrate a compelling "need" to policy makers, regulators, and permitting agencies
- The studies are **not transmission planning studies** that produce specific transmission projects that can be developed to deliver the identified benefits and they **do not support an actionable <u>need</u> for specific projects**
  - The results of these <u>studies do not connect with RTO planning processes and needs identification</u>
- Studies **do not to identify how benefits and costs are distributed** across utility service areas, states, or RTO/ISO under different scenarios, as would be necessary to gain support and develop feasible cost recovery options
  - The studies typically do not consider or propose how to recover ("allocate") transmission costs
- There has not been **an analysis of the state-by-state economic impact and job creation** from interregional transmission development, reduced electricity prices, and shifts in the locations of clean-energy investment
- Most studies do not **propose actionable solutions** to address the many barriers to planning processes and to the development of new interregional transmission projects

Offshore Wind Transmission

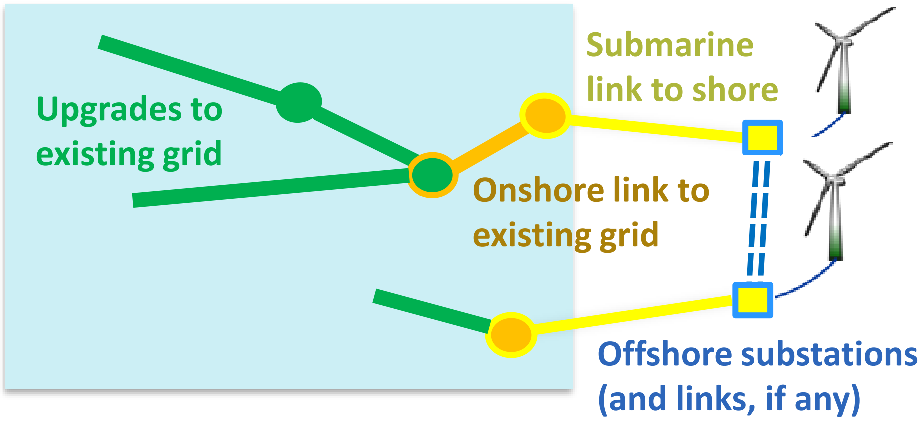
- OSW Transmission Configurations
- Advantages of Gen-ties vs. Planned Transmission
- Case studies: UK, New England, NY, NJ
- “Mesh Ready” OSW transmission

What will a Cost-effective OSW Transmission Solution Look Like for the Eastern U.S.?





Transmission Elements for Integrating Offshore Wind Generation



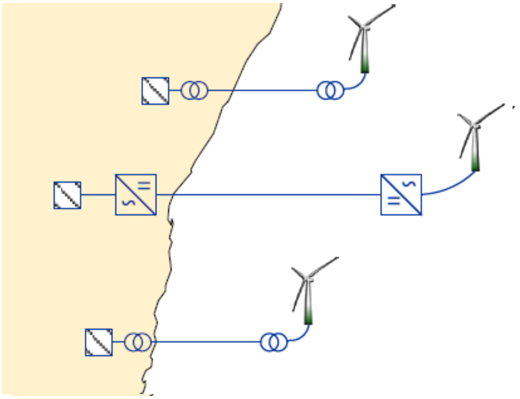
Transmission Planning Challenges for Offshore Wind Generation

- **The ISOs “generation interconnection” processes are workable for connecting offshore wind with <u>individual gen ties</u>**
  - Though ISOs existing generation interconnection study processes are challenging
    - Generators face long study timelines and highly uncertain network upgrade costs
    - Queue-based processes can reduce competition among OSW developers
  - Does not work well for large-scale OSW developments and offshore grids
- **ISO “regional transmission planning” processes often not ready to develop cost-effective plans for offshore grids in a timely fashion**
  - ISO regional planning processes are time consuming and often ineffective
    - Frequently undefined for addressing public policy needs
    - Exception: NYISO’s public-policy transmission planning process (PPTPP)
  - Limited ISO and stakeholder expertise with submarine transmission facilities and offshore transmission technology options
  - Developing a cost-effective offshore grid would require:
    - Pro-active, coordinated planning and permitting to develop onshore POIs, mitigate environmental impacts and project risks
    - Phased-in plan that aligns timing of transmission investments with generation development
    - Capturing synergies: offshore transmission to reinforce the on-shore grid

Offshore Transmission Concepts: Radial vs. Networked

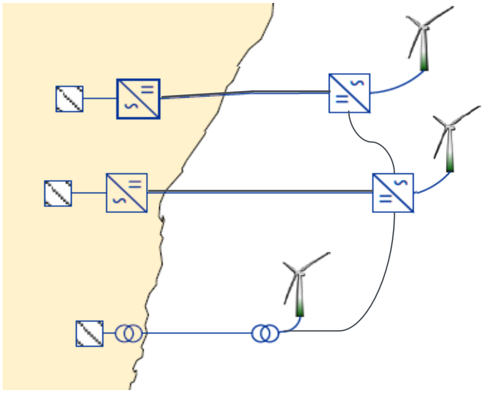
Radial Tie Lines

Transmission links bundled with individual OSW plants



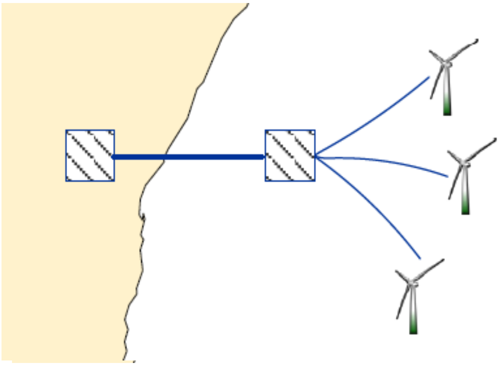
Meshed Generation Ties

Individual tie lines to shore linked through offshore transmission



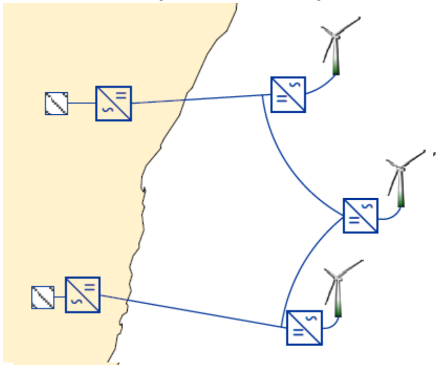
Shared Collector Station

Planned transmission tie lines for multiple OSW plants



Backbone Offshore Grid

Planned transmission tie lines for multiple OSW plants



Gen ties vs. "planned" OSW transmission alternatives:

- Radial generator tie lines built by OSW generation have been the prevailing approach for early rounds of OSW procurements
- Initially reduces project-on-project risk through joint G+T planning and development
- Planned OSW transmission allows for the long-term optimization of offshore and onshore transmission, in particular POIs
- Mitigates environmental impacts and reduces overall costs for generation, OSW transmission, and onshore upgrades

Gen-ties vs. Planned OSW Transmission Solutions

Factors favoring gen ties to individual offshore wind plants with HVAC links

- Modest total development and small incremental steps
  - 400 MW per HVAC circuit only
- Modest distance from shore
  - Ideally less than 40 miles
- Many landing points with robust on-shore transmission
  - Requires 3 HVAC circuits for every 1,200 MW of total OSW development
- Long distances between offshore locations to be interconnected
- Uncertain OSW lease areas
- Easy permitting of landing points and interconnection studies
- Wind developer has significant offshore transmission experience

Factors favoring offshore grids for multiple or large-scale wind plants with HVDC link

- Large size of total wind generation commitment with sizable procurement steps
  - 1,200-1,600 MW per HVDC circuit
- Several plants close to each other but long distances from shore or from sufficiently-robust onshore transmission nodes
- More efficient use of scarce right-of-way
  - Few landing points with robust on-shore transmission
  - Difficult permitting of landing points and onshore interconnection study process
- Meshed network option (offshore redundancy and reinforcement of on-shore grid)
- Independent transmission solutions to create:
  - more competition for wind developers through open access to offshore hubs
  - competition between experienced offshore transmission developers

Need to Mitigate Risk: Requires Well-Coordinated Generation and Transmission Development

- **Bundled development of OSW generation and radial transmission by single companies, mitigates offshore risks but faces increasing on-shore risks**
  - Reduces offshore project-on-project risks through coordination in joint planning and construction of OSW generation and transmission tie line
  - After "low-hanging" onshore interconnection points are utilized, this approach faces increased permitting risks and risks related to the costs and on-time completion of expensive onshore upgrades
- **Planned offshore transmission (e.g. NJ, Europe) can address project-on-project risks:**
  - Staggered transmission and generation project completion timelines (e.g., developing the offshore grid in segments that can completed in time for interconnection of individual generating plants)
  - Strong performance and completion incentives (rewards or penalties) for both transmission and generation developers to meet project deadlines
  - Allowing generation developer to participate in transmission procurement (with the condition that the transmission will be open access)

If only gen ties are used initially, scale procurement to 1200+ MW and add options so the lines can later be connected into a meshed OSW grid

Analyzing the Benefits of Planned Offshore Transmission

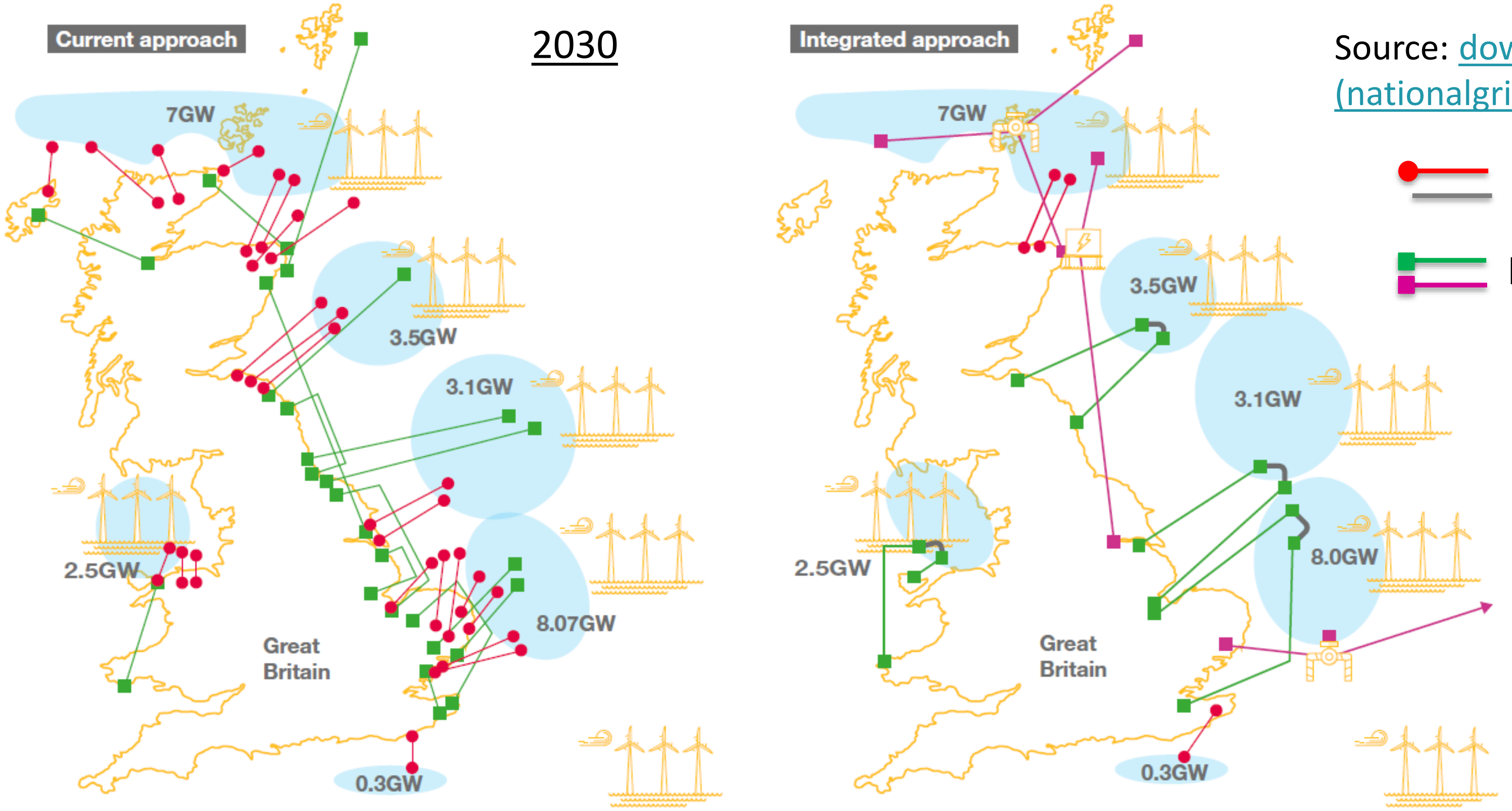
Studies of OSW transmission alternatives found that well-planned transmission (and procurement) can offer substantial advantages

Elements examined	A planned approach can…
Total onshore + offshore transmission • **Onshore transmission upgrades** • Offshore transmission	Lower overall long-term costs • **Substantially lower onshore costs** and project development risks • Slightly higher offshore costs
Losses over offshore transmission	Reduced losses
Impact on environment and fisheries	**Possibly substantially lower impacts**
Effect on generation & transmission competition	Increased competition
Utilization of constrained landing points	**Improved landing point utilization**
Enabling third-party customers	Improved third-party participation

Examples: Brattle-Anbaric OSW transmission studies for New York State and New England

NY Power Grid Study: routing 5-7 GW of OSW into NYC with high-capacity HVDC lines (that can be meshed to increase reliability) offers the best solution

Example: UK study of current and “integrated” OSW transmission approach for 18-41 GW by 2030-40



Source: [download (nationalgrideso.com)]

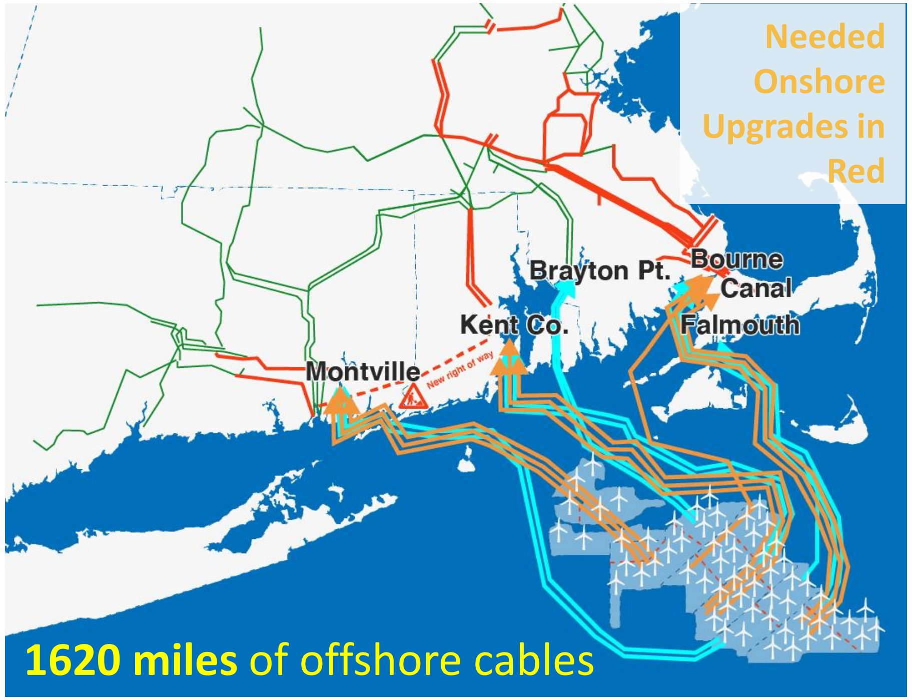
HVAC

HVDC

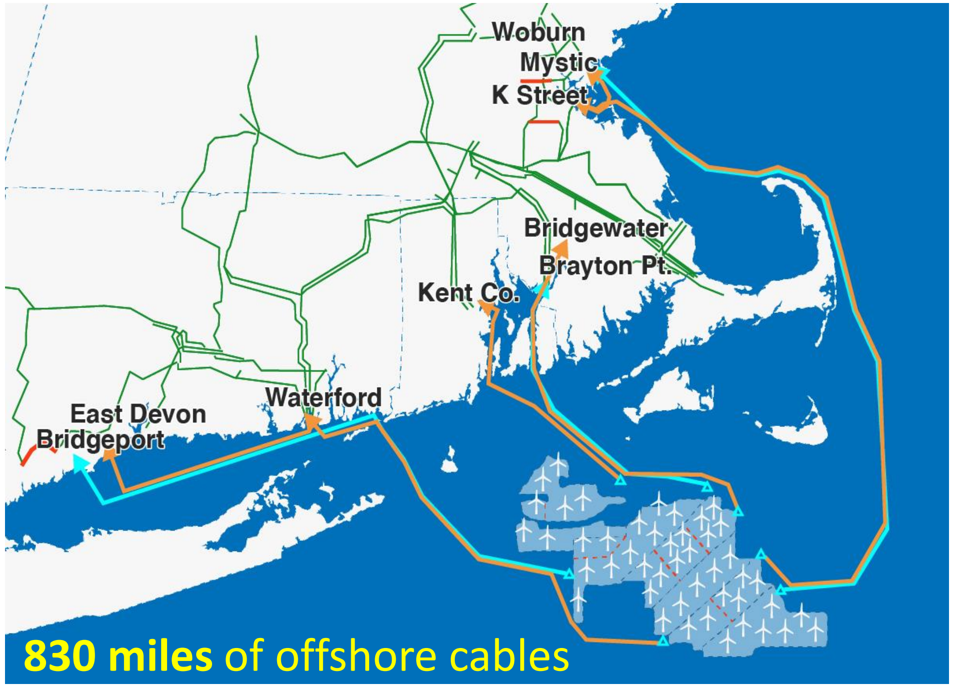
Results: if planning starts now, the **“integrated” solution reduces estimated transmission costs by 19% and the number of landing points by 50-70%**. Delaying planning by only 5 years reduces 2050 benefits by half.

Brattle-Anbaric Study: 2 transmission approaches studied for New England (~8,400 MW total OSW)

Plausible Gen Tie Approach



Planned Grid Approach

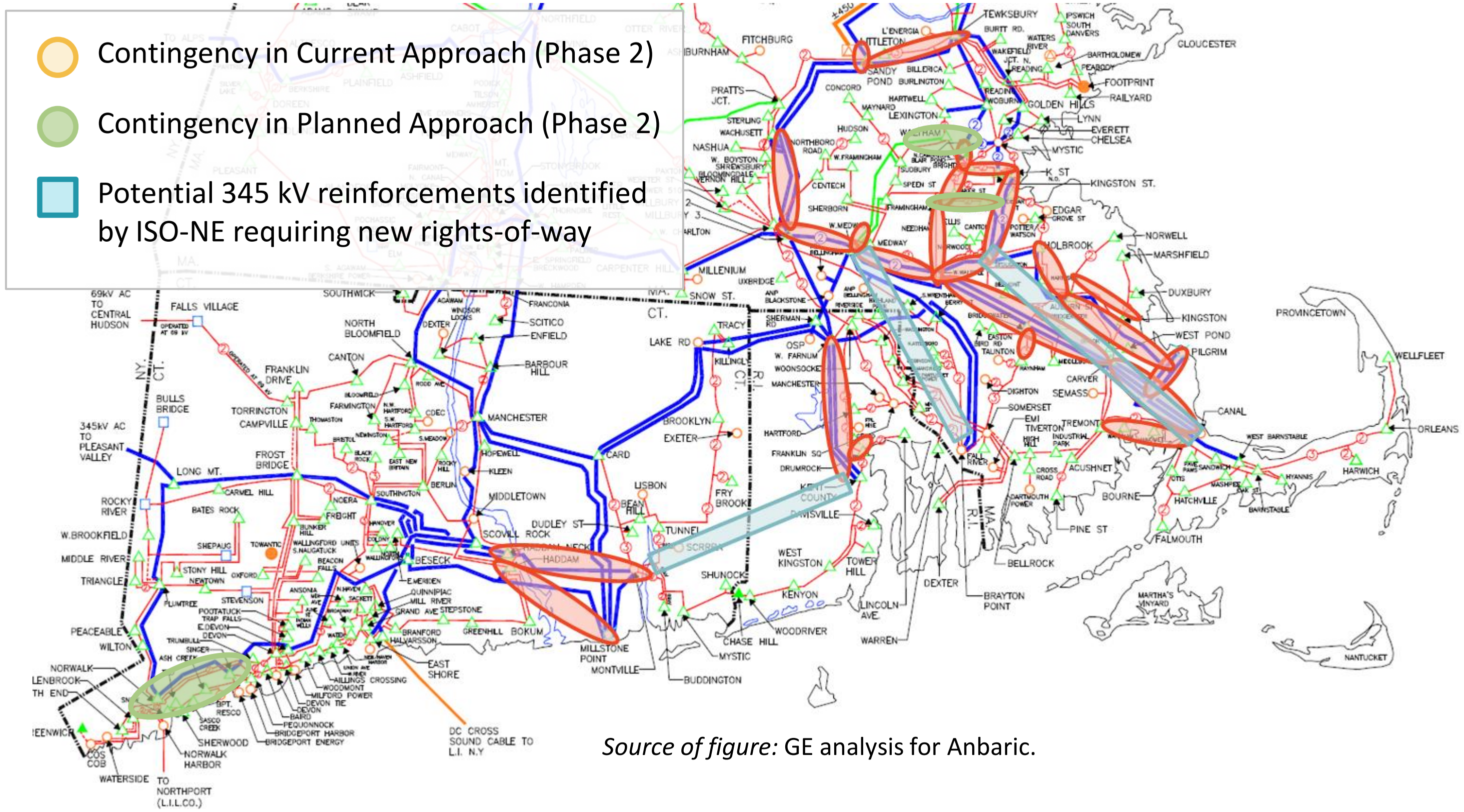


Reducing the number of offshore platforms, cabling, seabed disturbance, and cables landing at the coast **reduces impacts on existing ocean uses and marine/coastal environments** to the greatest practical extent

Avoiding high-costs of onshore upgrades reduces total costs and risks

Planning ahead avoids expensive and time-consuming onshore transmission upgrades

Already-selected New England projects connecting to Cape Cod face up to <u>$787 million</u> in onshore transmission upgrades,* and continuing this approach for even the next 3,600 MW of procurements could lead to an <u>additional $1.7 billion</u> in onshore upgrades



Source of figure: GE analysis for Anbaric.

Planned off-shore transmission can significantly reduce the necessary onshore upgrades.

Given the difficulty of permitting and building new onshore trans-mission, a planned approach also reduces the risk of cost overruns and delays

* ISO-NE's Feasibility Study for interconnecting three projects totaling 2,400 MW to Cape Cod (QP 828)

NYSERDA's Offshore Wind Integration Study

NYSERDA's OSW Study assessed bulk transmission needs for 9,000 MW of offshore-wind generation by 2035

- "**Onshore** assessment" to identify points of interconnection (POIs) and on-shore bulk-power transmission upgrades
- Development of **offshore** buildout scenarios from wind energy areas to selected POIs
  - Analyze offshore transmission to connect OSW plants
- Preliminary **permitting and feasibility** study of offshore cable routes and onshore landing points

Findings:

- Integrating 9,000 MW of OSW is feasible without major near-term bulk transmission upgrades if: 5,000-7,000 MW of OSW can be routed into NYC (so only 2,000-4,000 MW connect to the grid on L.I.)
  - New transmission from Long Island likely needed by 2030-35 (PPTN is already initiated)
  - Significant uncertainty about POIs and lease areas (OSW Study vs. contracts vs. other studies)
- Requires careful planning of OSW procurement, battery deployment, coordinated routing and permitting, and well-planned integration into local NYC grid (possibly through local "OSW hubs" as proposed by ConEd)
- Pursue options that allow for a **more flexible and reliable "meshed" offshore grid**

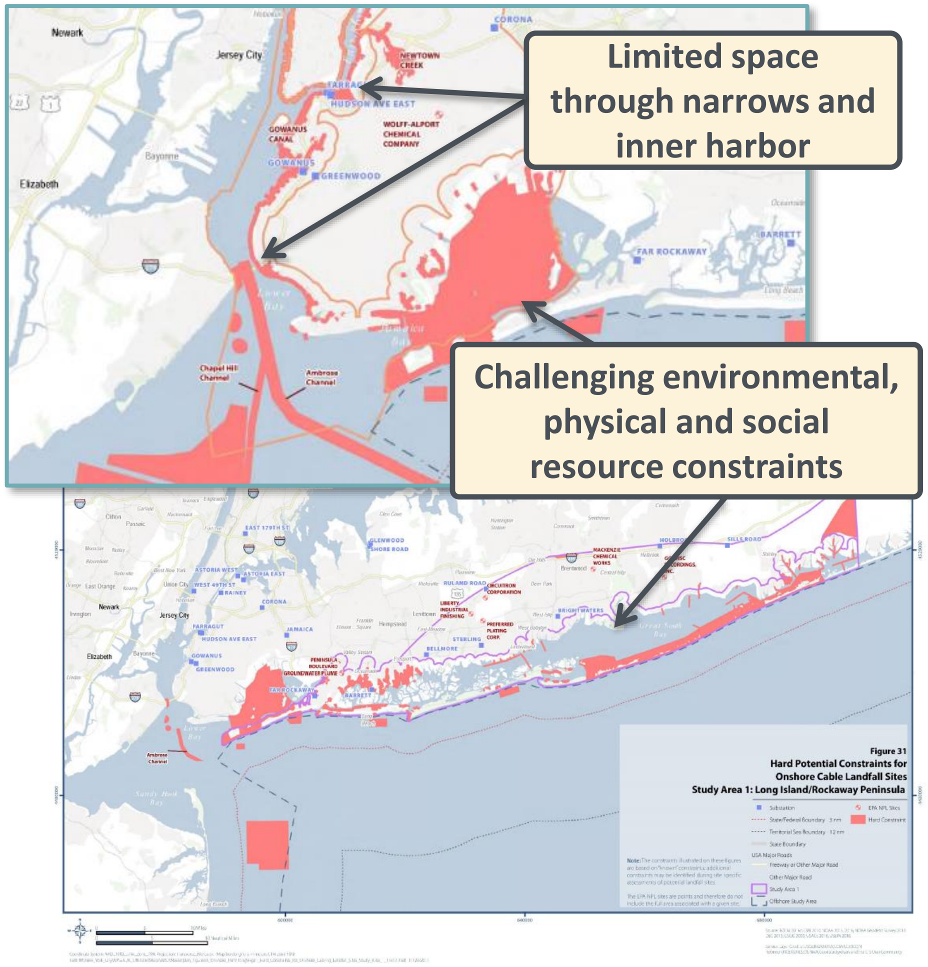
Constrained NYC access routes require well-coordinated routing, permitting, and planning

There are a limited number of robust POIs for connecting offshore wind to the onshore grid and limited access routes to these POIs

If each OSW project builds its own gen ties to the onshore transmission system (without coordination), **viable landing sites and cabling routes will become constrained. A well-coordinated planned transmission approach can make better use of the limited landing sites**

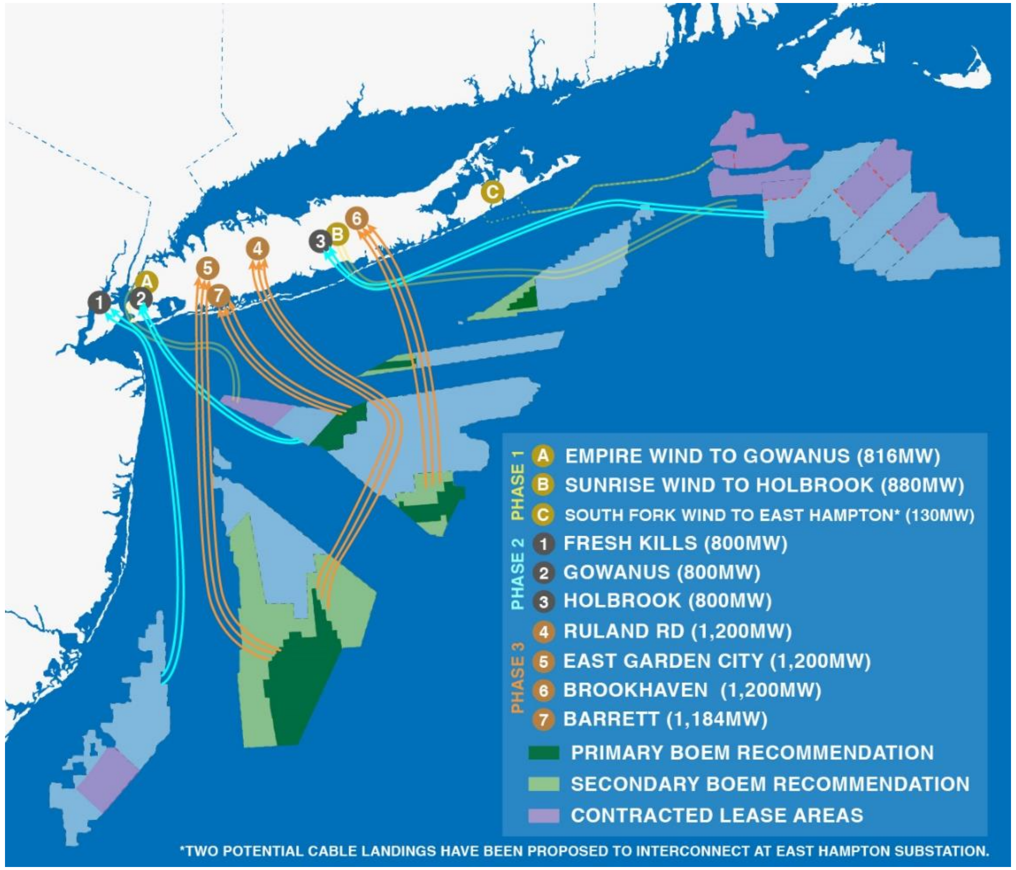
The clearest example of this is the cable approach route through the Narrows to reach POIs in New York's inner harbor

Landing Limitations along NY Coast



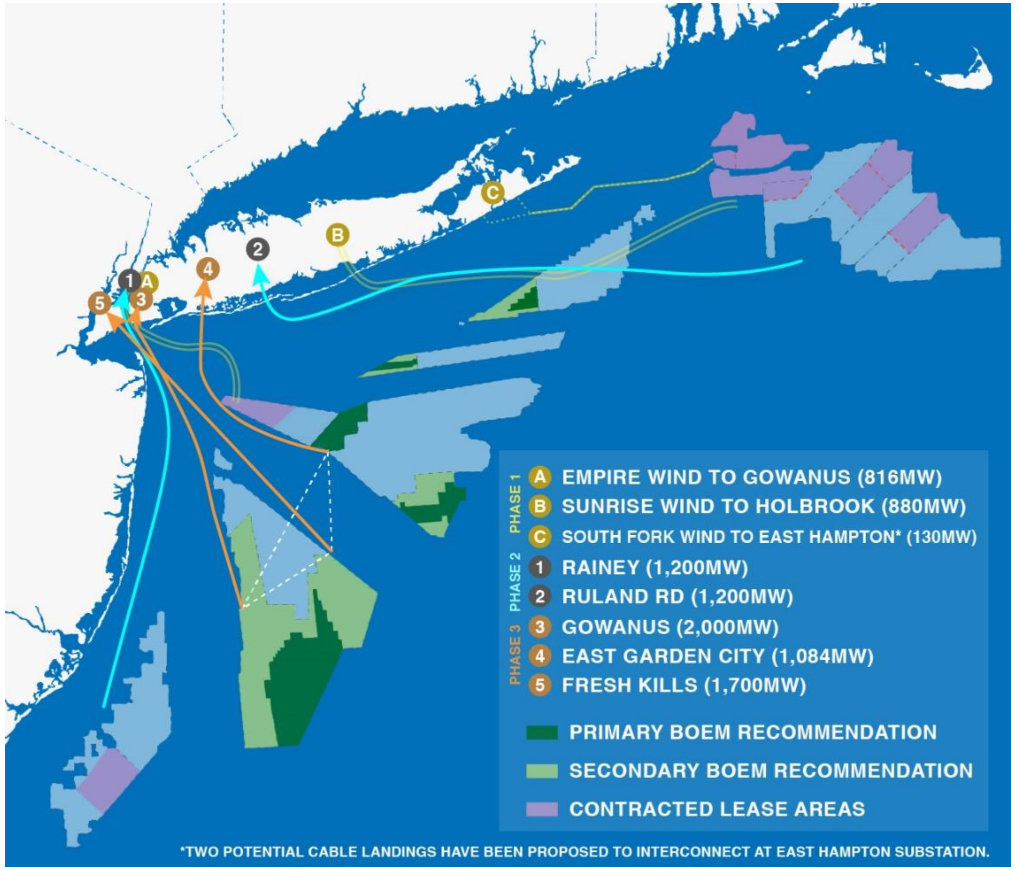
Brattle-Anbaric Study for New York: alternative transmission approaches for 9,000 MW of OSW

Higher-Impact: HVAC Gen Ties

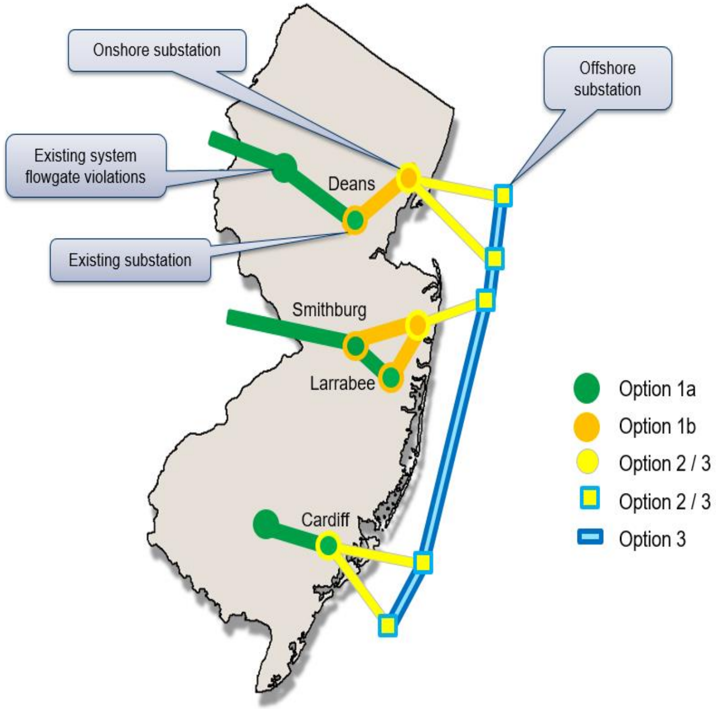


Note: Phase 1 is already contracted using HVAC cables.
NYSERDA since has provisionally awarded two additional projects for 2490 MW, interconnecting into the Astoria (using HVDC) and Barrett substations.

Lower Impact: Planned HVDC Grid



Pro-active PJM Solicitation of OSW Transmission for NJ



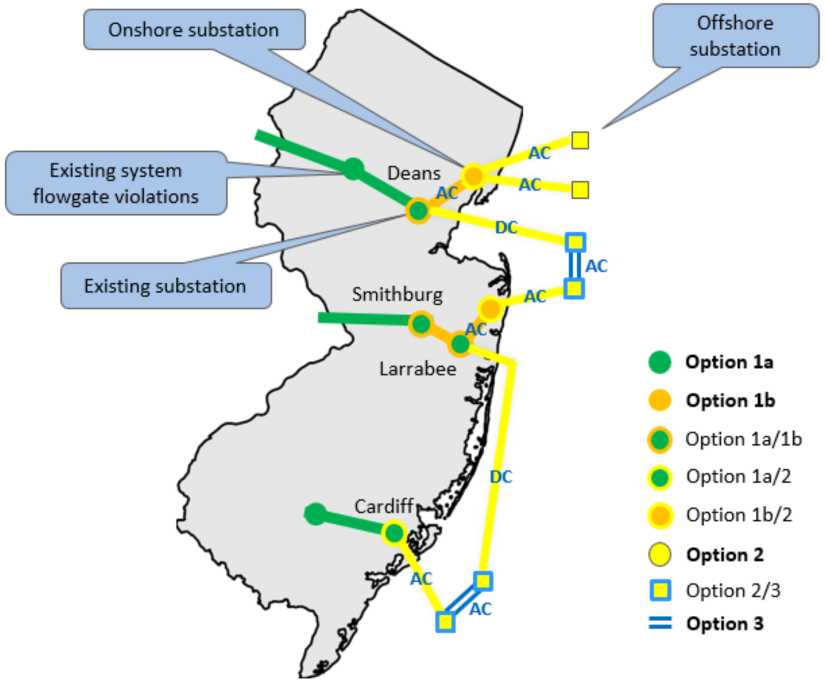


Illustration of "Options"

Option 1a - Onshore Upgrades on Existing Facilities

Option 1b - Onshore New Transmission Connection Facilities

Option 2 - Offshore New Transmission Connection Facilities

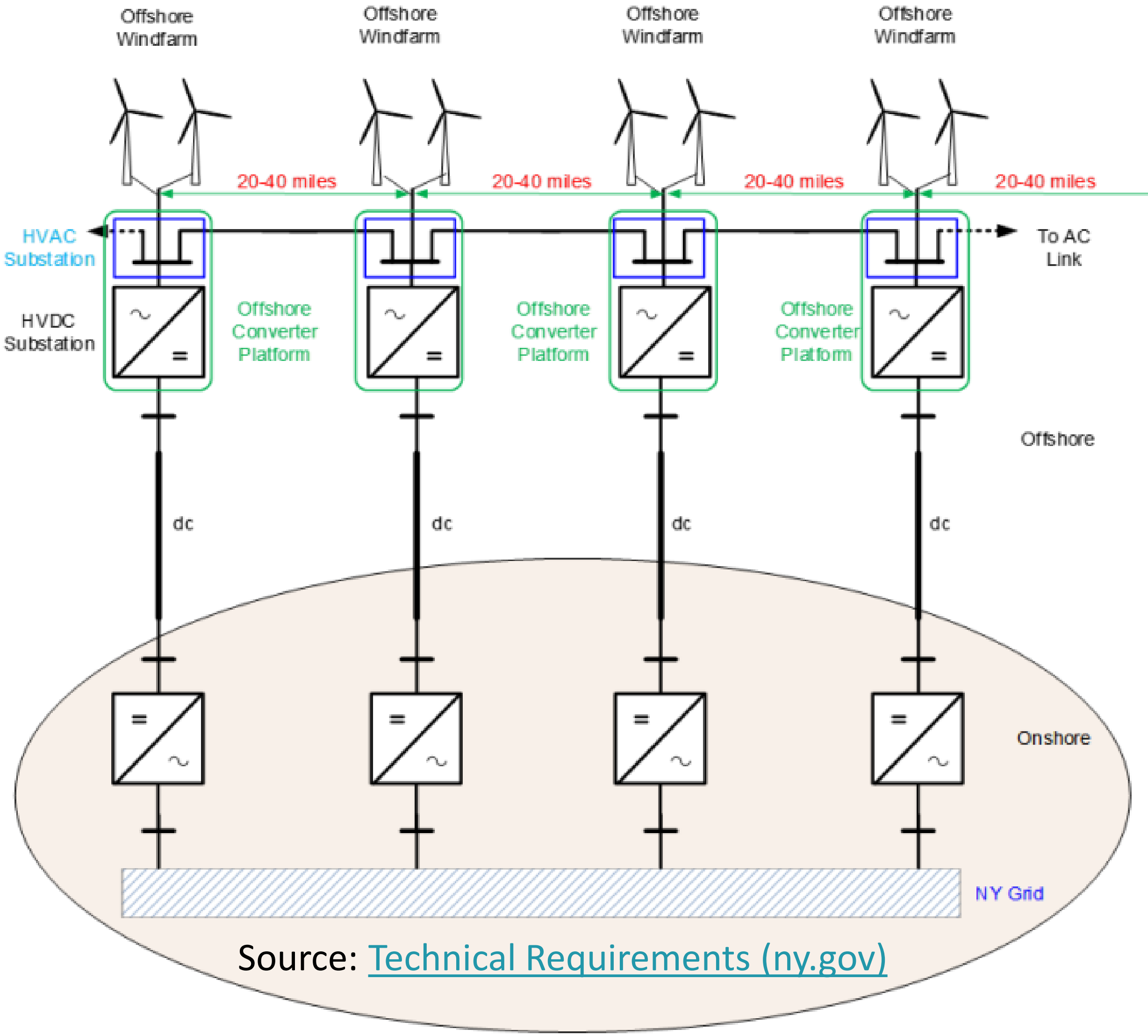
Option 3 - Offshore Network

Source: https://www.pjm.com/planning/competitive-planning-process.aspx

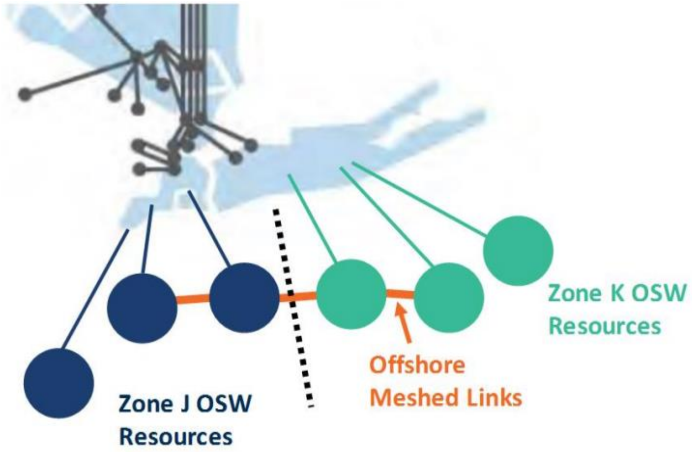
PJM Summary of bids: 20220308-item-08-nj-osw-saa-update-proposal-overview.ashx (pjm.com)

- PJM's first-ever transmission solicitation under its State Agreement Approach (SAA):
  - Solicitation for transmission solutions for NJ's public policy need to integrate up to 7,500 MW of OSW generation (net of prior procurements)
  - Bids can address individual elements (Options 1a-3) or offer complete solutions
- Received 80 innovative proposals from 13 bidders are currently evaluated by PJM and the NJBPU
  https://nj.gov/bpu/pdf/publicnotice/Notice%20SAA%20Public%20Stakeholder%20Meeting.pdf

Design, Benefits, and Costs of Meshed HVDC OSW Transmission



Source: Technical Requirements (ny.gov)



Study estimates $60 million of annual meshed link benefits (plus outage mitigation, onshore reliability, resilience, and operational benefits)

NYSERDA's Meshed Grid Study:

- Procuring OSW plants with "mesh-ready" offshore HVDC substations adds only approximately $40 million (1%) to the total cost of a 1,200 MW plant
- HVDC offshore substations can be (later) be meshed at a cost of $120-240 million per link

NYSERDA Draft RFP for 2022 OSW Solicitation (for at least 2,000 MW) requires each proposal to utilize HVDC technology and meet mesh-ready standards

Takeaways

Implications for U.S. OSW Transmission

U.S. offshore wind development will require substantial offshore and supporting onshore transmission infrastructure

- The ~30,000 MW of committed off-shore wind development in the Eastern U.S. will require **1,500 to 3,000 miles of offshore transmission** plus significant onshore reinforcements
- For example: to integrate 30,000 MW with radial 220kV HVAC **gen-ties** for every 400 MW of wind generation (up to 30-60 miles offshore) would require about **3000 miles of offshore cables to 75 landing points** with associated onshore grid reinforcements
- **Planned off-shore grids** for larger wind plants and to optimize onshore grid capabilities—such as used in Germany, the Netherlands, Belgium, and proposed for NJ and MA—would yield scale economies, more resilient meshed grids, and only about **1500 miles of cables with 25 landing points**
  - Proactive planning is necessary to **identify the most attractive POIs** with acceptable environmental impact and cost-effective upgrades to the onshore grid

Advantages of Pro-active Planning for OSW Transmission

Planning transmission solutions for OSW generation offers distinct disadvantages over OSW procurements that leave transmission solution with individual generators:

- Less cost-efficient POIs selected through uncoordinated generation interconnection processes
- Increased environmental impact on seabed and shoreline to reach POIs
- Reduced competition for transmission and off-shore wind generation
- Higher onshore transmission costs and higher total costs in the long run

A planned approach is better suited to support the large scale of states' OSW goals:

- Reduce number of cables and landing points
- Reduced need for onshore transmission upgrades through pro-active planning
  - Select more optimal POIs consistent with long-term needs (even if not lowest-cost in short run)
- Consider competitive solicitations for OSW transmission and POIs (e.g., 7500 MW by NJ BPU)

"Mesh Ready" Procurements: create options that utilize ROW efficiently and allow evolving from gen-ties to a meshed offshore grid

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Johannes (Hannes) Pfeifenberger, a Principal at The Brattle Group, is an economist with a background in electrical engineering and over twenty-five years of experience in wholesale power market design, renewable energy, electricity storage, and transmission. He also is a Visiting Scholar at MIT's Center for Energy and Environmental Policy Research (CEEPR), a Senior Fellow at Boston University's Institute of Sustainable Energy (BU-ISE), a IEEE Senior Member, and currently serves as an advisor to research initiatives by the U.S. Department of Energy, the National Labs, and the Energy Systems Integration Group (ESIG).

Hannes specializes in wholesale power markets and transmission. He has analyzed transmission needs, transmission benefits and costs, transmission cost allocations, and transmission-related renewable generation challenges for independent system operators, transmission companies, generation developers, public power companies, industry groups, and regulatory agencies across North America. He has worked on transmission, resource adequacy, and wholesale power market design matters in SPP, MISO, PJM, New York, New England, ERCOT, CAISO, WECC, Alberta and Ontario.

He received an M.A. in Economics and Finance from Brandeis University's International Business School and an M.S. and B.S. ("Diplom Ingenieur") in Power Engineering and Energy Economics from the University of Technology in Vienna, Austria.

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Brattle Reports on Regional and Interregional Transmission Planning and Benefit-Cost Analyses

Well-Planned Electric Transmission Saves Customer Costs:
Improved Transmission Planning is Key to the Transition to a Carbon-Constrained Future

PREPARED FOR
WIRES

Link: Well-Planned Transmission

PREPARED BY
Judy W. Chang
Johannes P. Pfeifenberger

May 2016

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Toward More Effective Transmission Planning:
Addressing the Costs and Risks of an Insufficiently Flexible Electricity Grid

PREPARED FOR
WIRES

Link: Effective Transmission Planning

PREPARED BY
Johannes P. Pfeifenberger
Judy W. Chang
Akarsh Sheilendranath

April 2015

The Brattle Group

Link: Transmission Benefits

The Benefits of Electric Transmission: Identifying and Analyzing the Value of Investments

July 2013

Judy W. Chang
Johannes P. Pfeifenberger
J. Michael Hagerty

Link: Diversity Value

BU
Boston University Institute for Sustainable Energy

The Value of Diversifying Uncertain Renewable Generation through the Transmission System

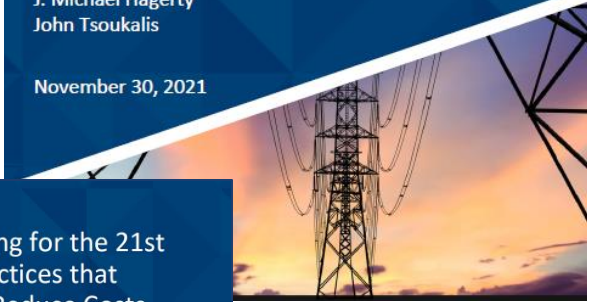
September • 2020

A Roadmap to Improved Interregional Transmission Planning

Link: Interregional Roadmap

PREPARED BY
Johannes P. Pfeifenberger
Kasparas Spokas
J. Michael Hagerty
John Tsoukalis

November 30, 2021



Transmission Planning for the 21st Century: Proven Practices that Increase Value and Reduce Costs

Link: Brattle Grid Strategies

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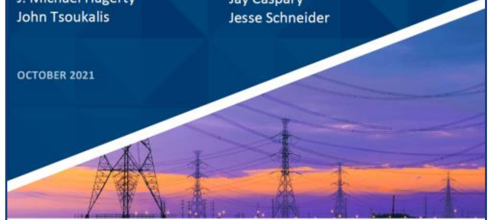

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Summarizes proven approaches to quantifying various benefits

Additional Reading on Transmission

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Pfeifenberger, Chang, and Sheilendranath, "Toward More Effective Transmission Planning: Addressing the Costs and Risks of an Insufficiently Flexible Electricity Grid," WIRES and The Brattle Group, April 2015.

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