Promoting Efficient Investment in Offshore Wind Transmission

PRESENTED BY

Johannes Pfeifenberger

PRESENTED AT

DOE-BOEM Atlantic Offshore Wind Transmission Economics & Policy Workshop

AUGUST 16, 2022

Brattle

Contents

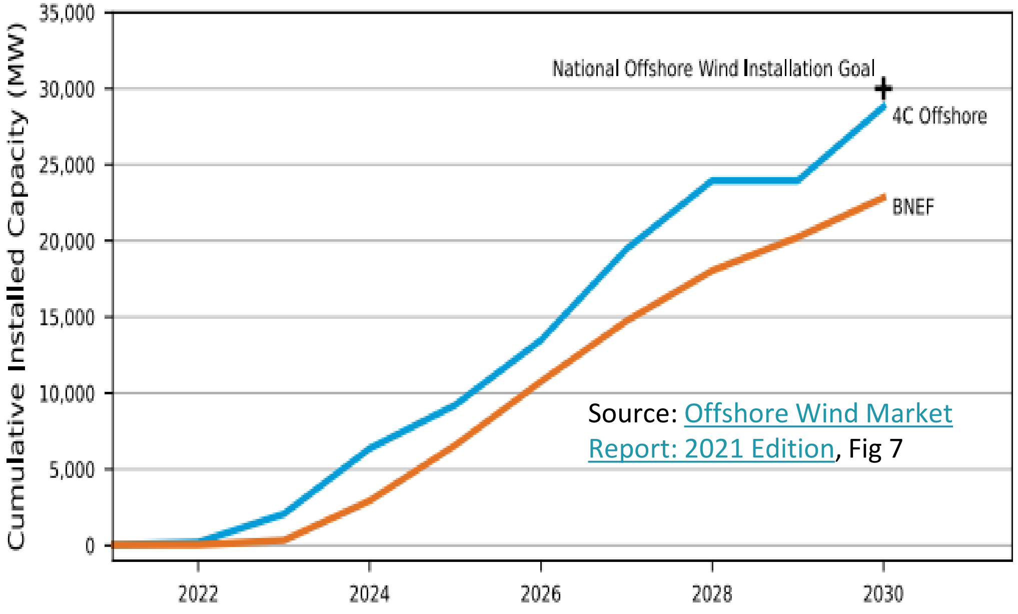
Starting Point: Substantial OSW Generation Commitments

Thousands of MW of new clean resources will need to be built to achieve state decarbonization goals—including substantial offshore wind beyond the **39,000 MW** of current commitments in eastern U.S.

A key challenge: **ensuring a pathway low-cost, low-impact solutions** for delivering a projected 110 GW of OSW generation to onshore grid and population centers by 2050

Region	Already Contracted	Total Committed	Potentially Needed
New England	4,840 MW	8,600 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	14,300 MW	

Sources: **Contracted and committed**: ACP_FactSheet-Offshore_Final (cleanpower.org), 2021. Offshore Wind Energy Strategies Report (2022), https://www.newenglandforoffshorewind.org/states/overview/.
Potentially needed: Brattle Study of NE by Jurgen Weiss and Michael Hagerty, "Achieving 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.



Source: Offshore Wind Market Report: 2021 Edition, Fig 7

Transmission Planning for OSW Generation: Today

- **The ISOs "generation interconnection" processes are workable for connecting offshore wind with individual gen ties**
  - Though the ISOs' existing generation interconnection study processes are increasingly challenging
    - Generators face multi-year study timelines and highly uncertain network upgrade costs
    - Queue-based processes inefficient and can reduce competition in OSW generation procurements
  - Does not work well to find cost-effective solutions for large-scale OSW developments and offshore grids
- **ISO "regional transmission planning" processes not yet ready to develop cost-effective plans for offshore grids in a timely fashion**
  - ISO regional planning processes are time consuming and often ineffective
    - Frequently insufficiently defined for addressing offshore wind generation needs
    - Steps in the right direction: NYISO's public-policy transmission planning process (PPTPP); PJM's state agreement approach (SAA)
    - Onshore models: SPP Integrated Transmission Planning, MISO Multi-Value Transmission Planning

U.S. Transmission Planning is Balkanized

Local TO Reliability Projects
Upgrades to meet local standards

Generator Interconnection (GI) Projects
Reliability upgrades for GI requests

Long Term Transmission Service Projects
Reliability upgrades for Tx Service Requests

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)

Generation interconnection processes often have become the primary tool (and barrier) to support public policy goals for clean energy

Current RTO Regional Transmission Planning Processes

Regional Reliability Projects
Addresses remaining reliability needs

Regional Economic & Public Policy Projects
Often addresses only a narrow set of remaining needs

Planning for economic & public-policy projects results in less than 10% of all U.S. transmission investments

Joint RTO *Interregional* Planning Processes
View of remaining needs is often narrow, resulting in few to no projects

Interregional planning processes are large ineffective

- Essentially no major interregional transmission projects have been planned and built in the last decade
- Numerous national studies show that more interregional transmission is needed to reduce total system costs

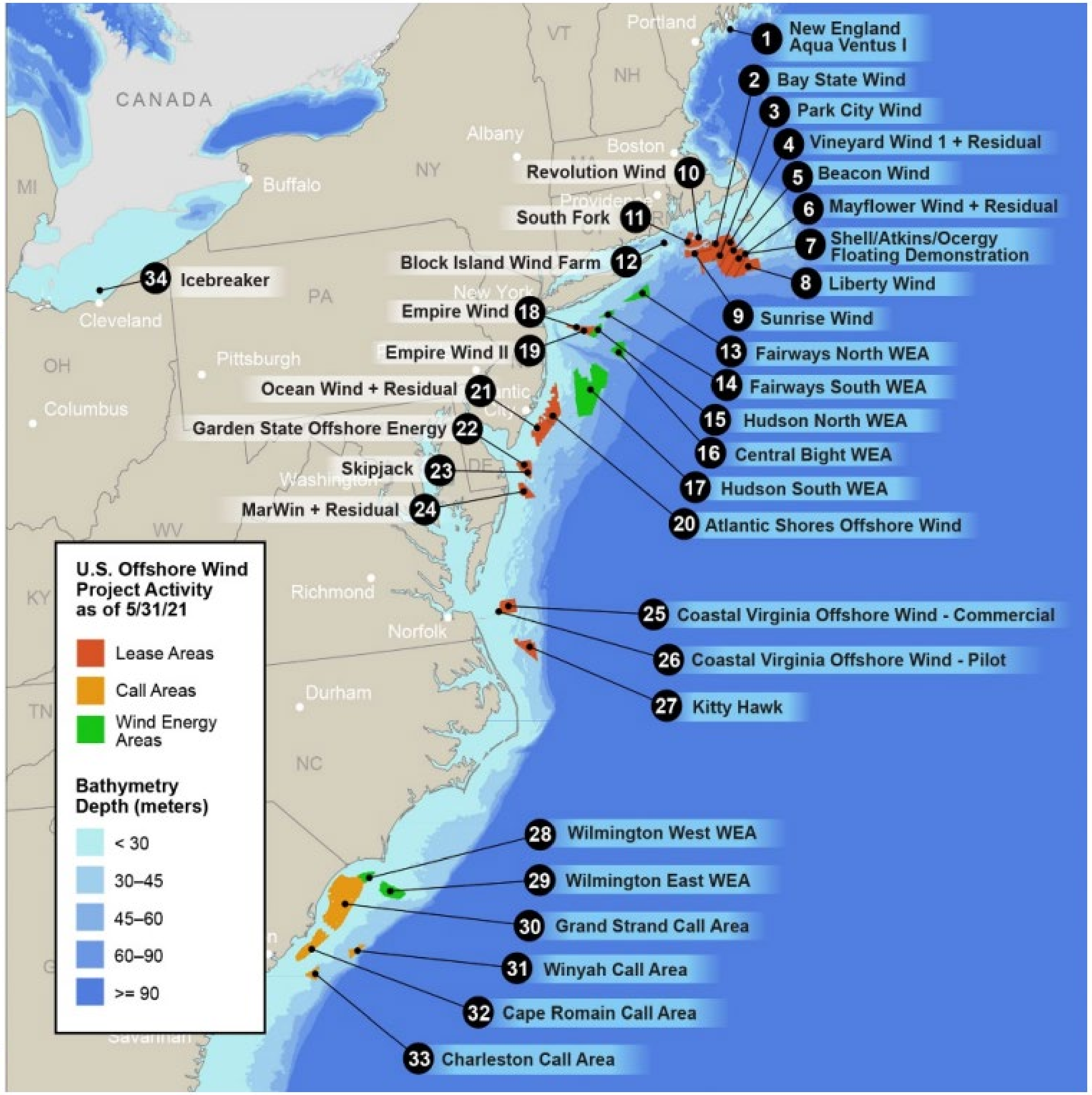
Proposal: Transmission Planning for the 21st Century*

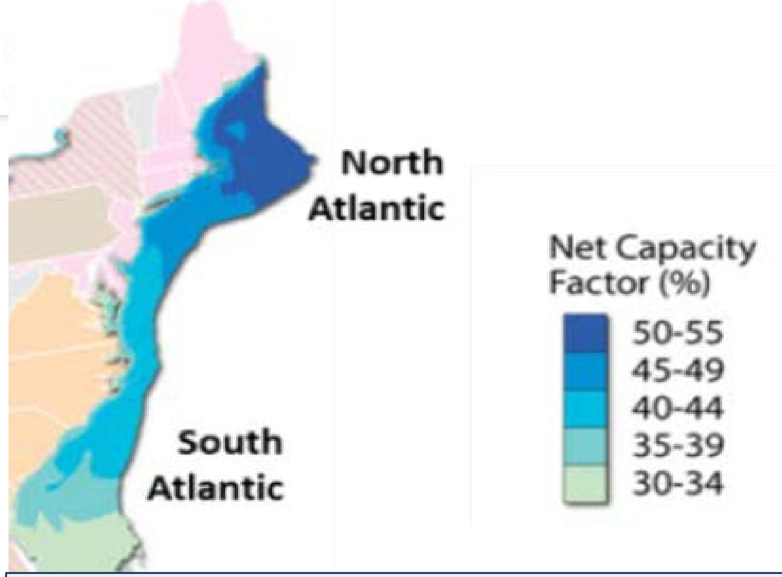
FERC NOPR efforts and available experience point to proven planning practices that can reduce total system costs and risks, but are rarely used today:

1. **Proactively plan 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 full range of transmission projects' benefits** and **use multi-value planning** to comprehensively identify investments that cost-effectively address all categories of needs and benefits
3. **Address uncertainties and high-stress grid conditions explicitly through scenario-based planning** 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 network portfolios** to address system needs and **cost allocation** more efficiently and less contentiously than a project-by-project approach
5. **Jointly plan inter-regionally across neighboring systems** to recognize regional interdependence, increase system resilience, and take full advantage of interregional scale economics and geographic diversification benefits

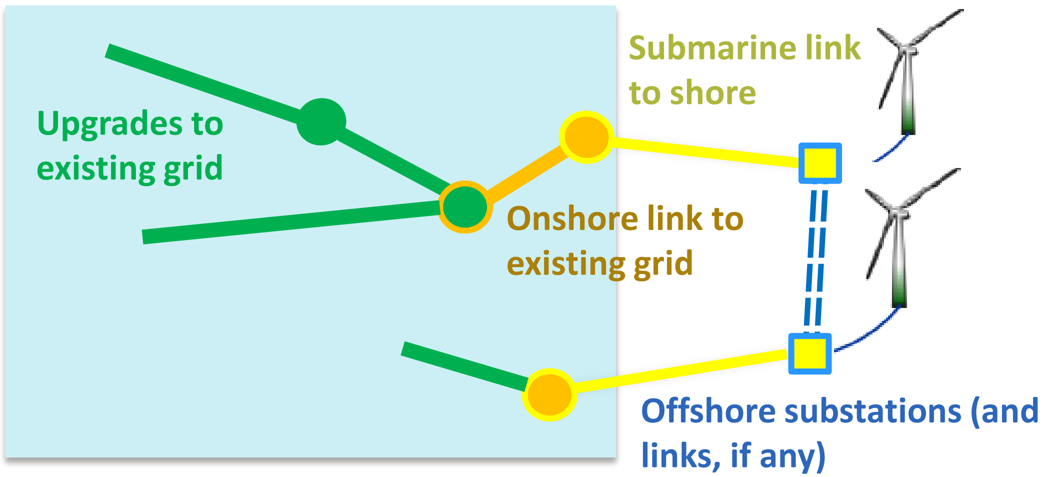
* Brattle & Grid Strategies Report: Transmission Planning for the 21st Century: Proven Practices that Increase Value and Reduce Costs, October 2021.

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





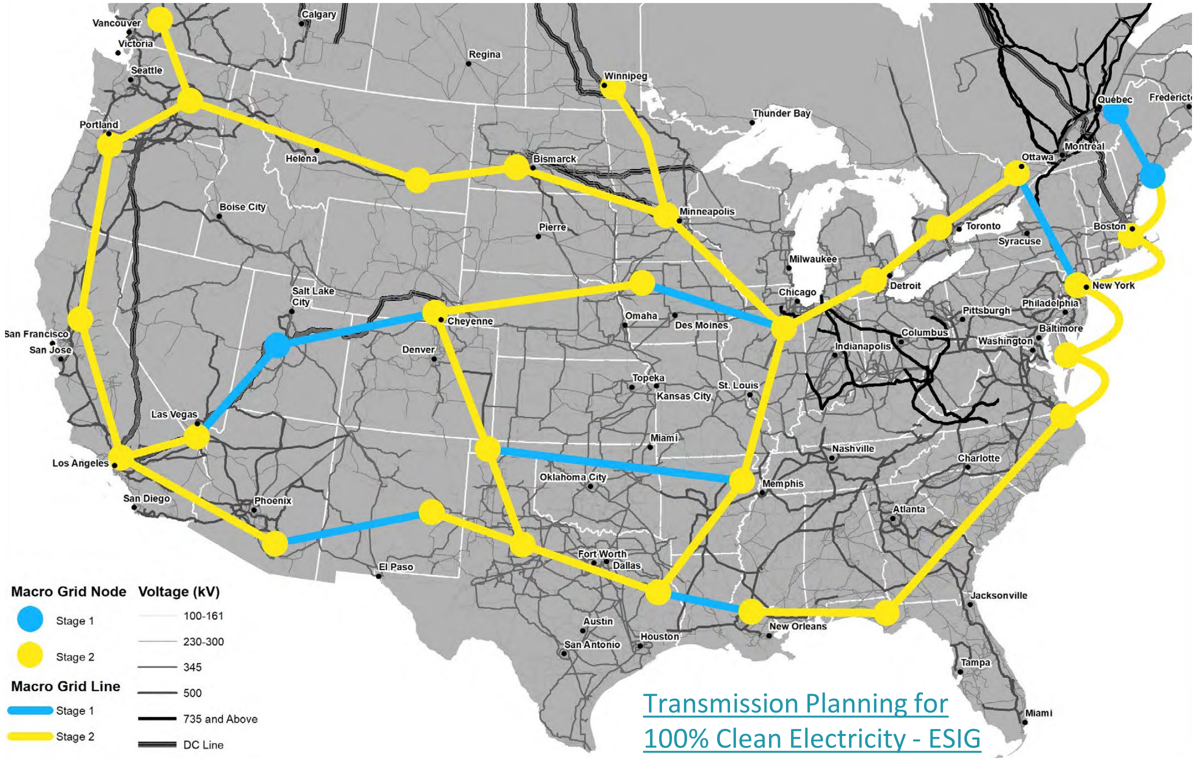
Distinct Transmission Elements for Integrating Offshore Wind Generation



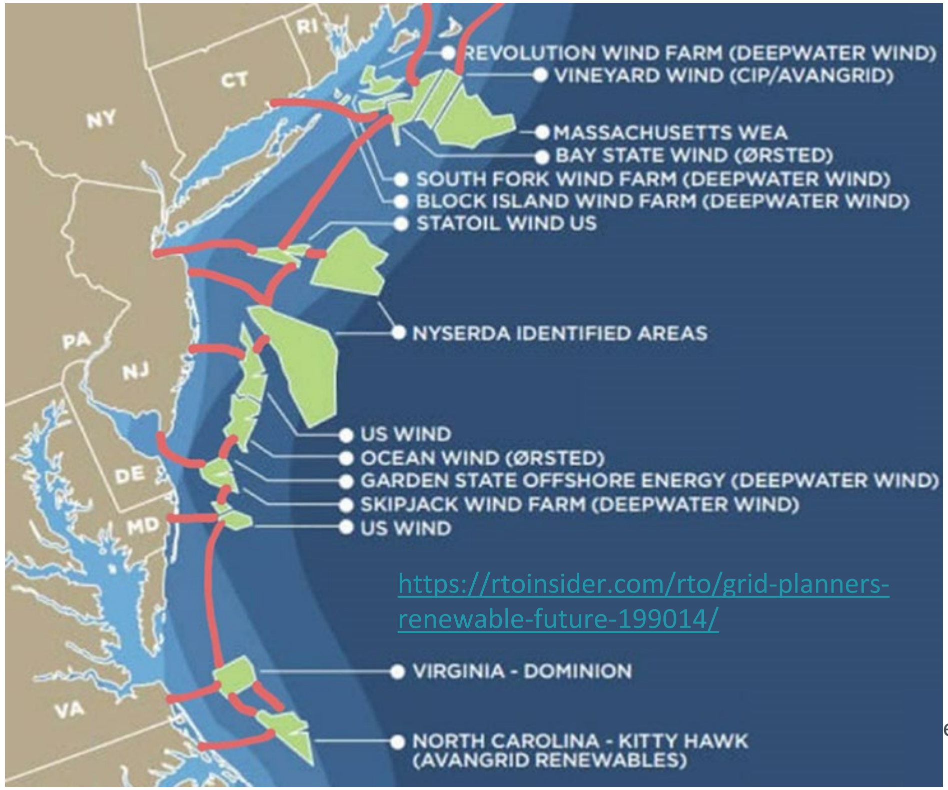
Long-term Visions: Will OSW generation be integrated into a more geographically-diverse inter-regional grid?

As state and regional shares of renewable generation increase, a robust inter-regional grid <u>ultimately</u> 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/]

Numerous Barriers to Transmission Planning & Development Make These Visions Currently Unachievable

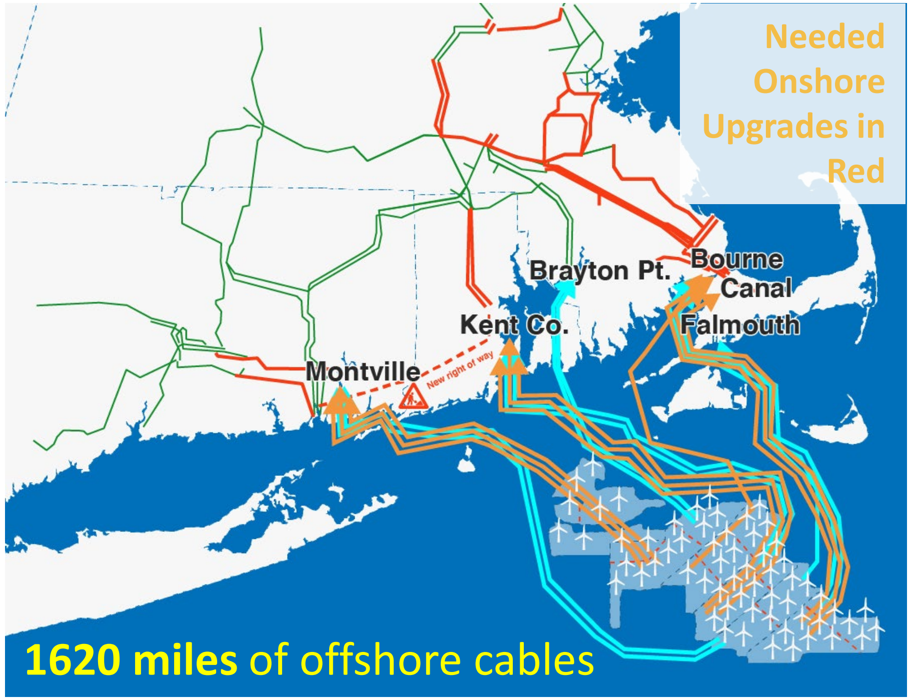
A. Leadership, Alignment and Understanding	1. Insufficient leadership from RTOs and federal & state policy makers to prioritize interregional planning 2. Limited trust amongst states, RTOs, utilities, & customers 3. Limited understanding of transmission issues, benefits & proposed solutions 4. Misaligned 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.

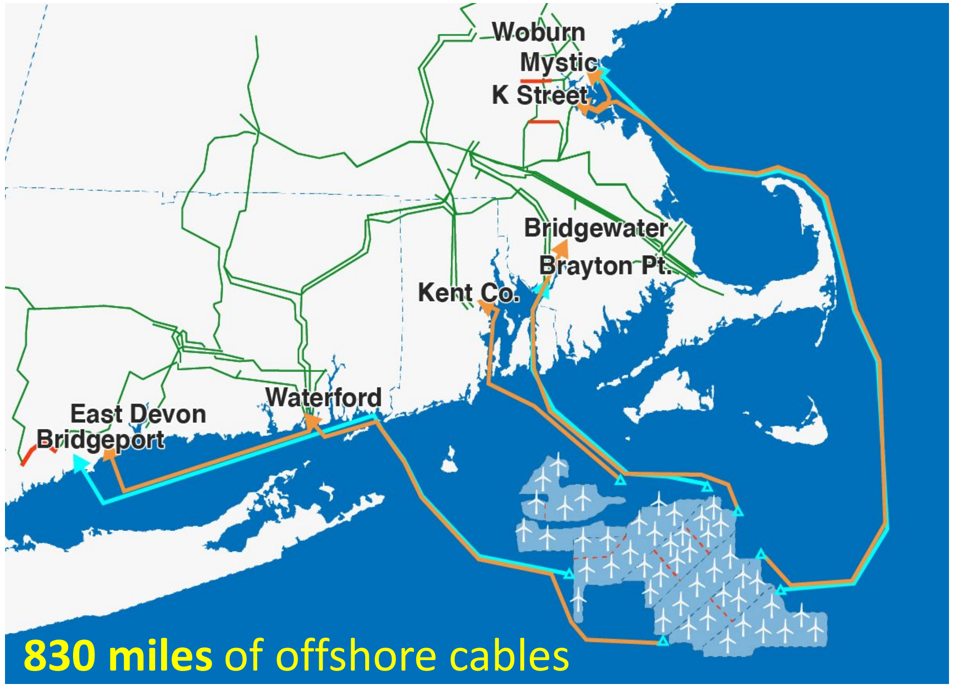
Contents

Brattle-Anbaric Study: Alternative Transmission Approaches for New England (for 8,400 MW total OSW)

Plausible AC Gen-Tie Approach



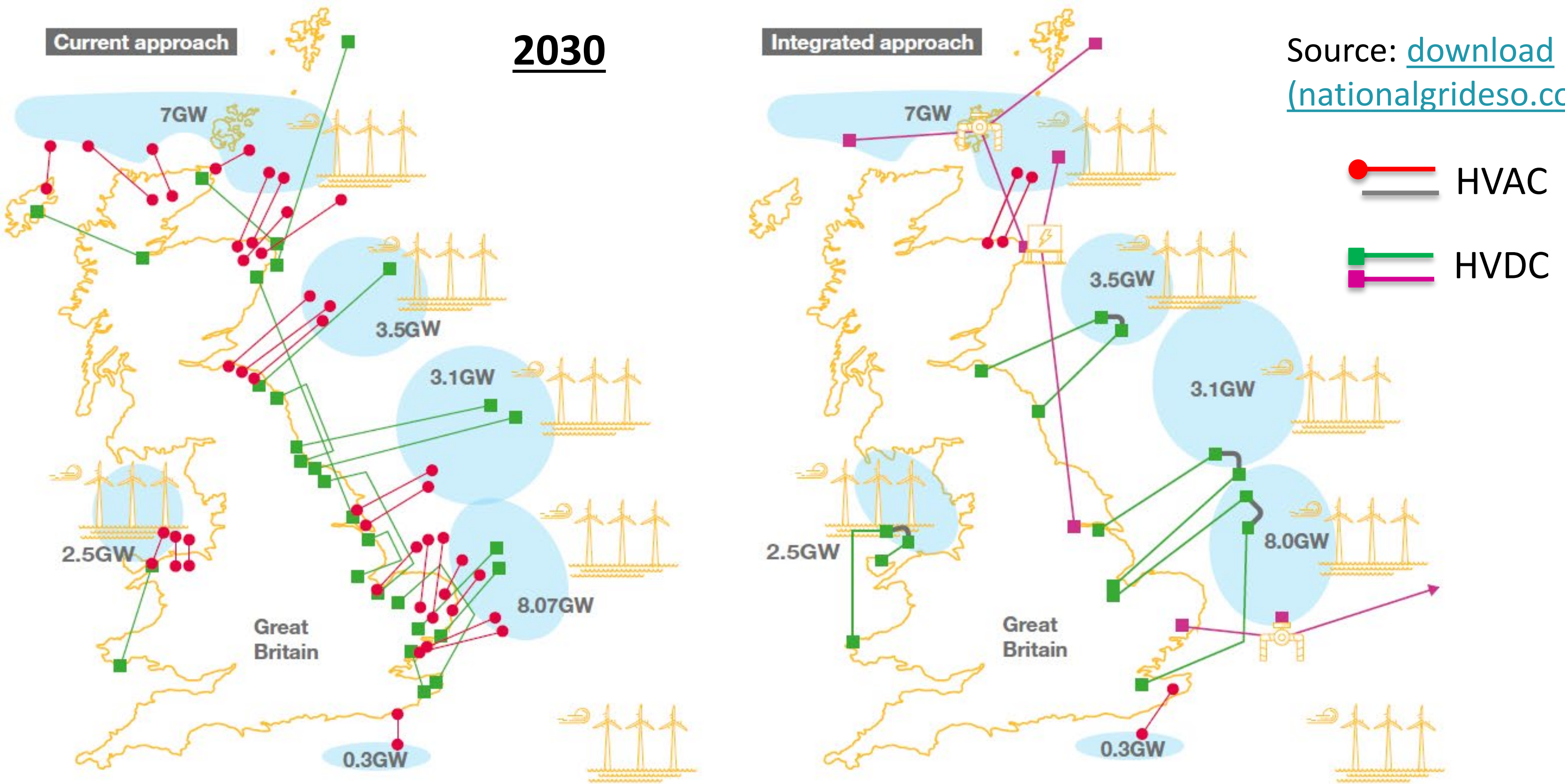
Planned HVDC+POI Approach



1. Higher-capacity HVDC lines: 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

2. Proactively-planned POIs: **Avoiding high-costs onshore upgrades reduces total costs and risks** of utilizing the current generation interconnection process

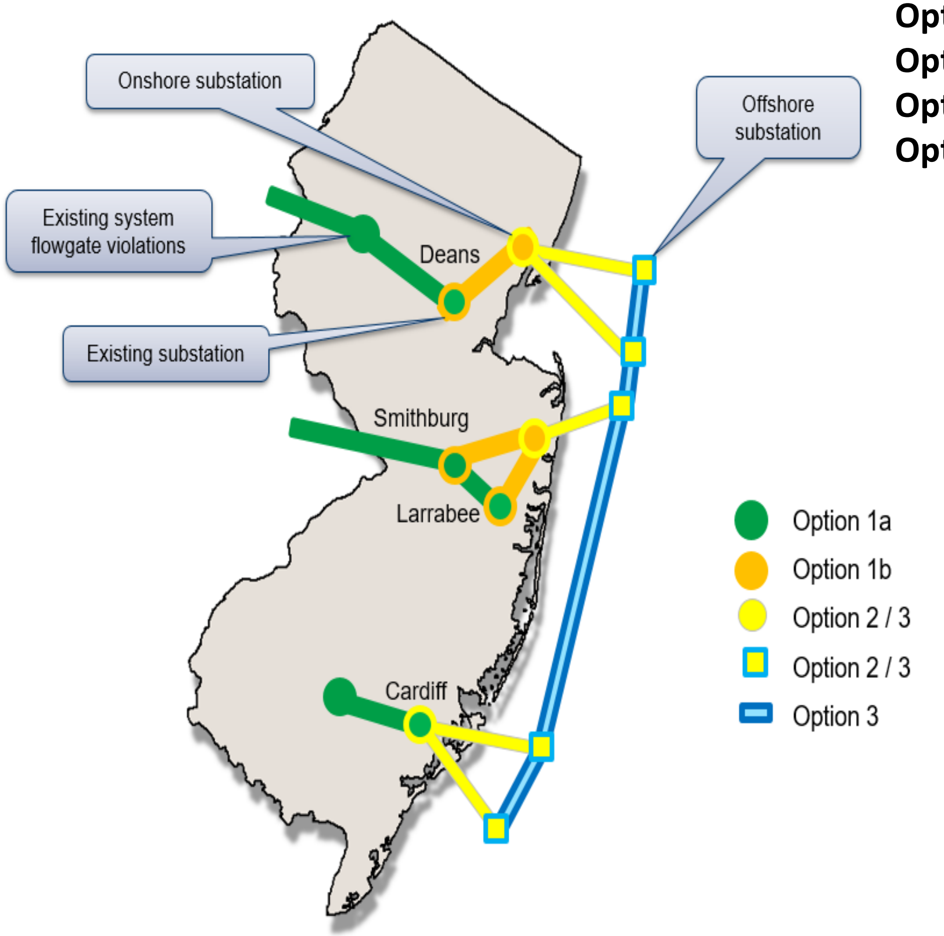
Example: UK Study of Current and "Integrated" OSW Transmission Approach for 18-41 GW by 2030-40



Source: [download (nationalgrideso.com)]

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.

Happening Now: PJM's SAA for NJ OSW Transmission



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)

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

- 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
- 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
- **PJM summaries of 1a upgrades: substantially lower costs than upgrades identified in individual GI studies to date**
- Awards by the BPU expected for this Fall

Current Challenges to Planned OSW Transmission in the U.S.

1. Ineffective generation-interconnection and regional transmission planning processes
   - Generation queue processes needlessly cumbersome, time-consuming, and inefficient
   - RTOs unable to even identify the most attractive onshore Points of Interconnection (POIs) that could meet states’ combined OSW commitments at lowest total costs and risks
2. Timeline of current procurement goals not easily compatible with multi-year effort of developing and implementing a regional planning process for OSW transmission
   - Supply-chain challenges and project-on-project risk only add to near-term planning hurdles
3. Federal tax credits (30+% ITC) available only to OSW generators and their connections to shore, but not for independent offshore transmission
4. Rapid technological progress and lack of standards for offshore transmission makes it challenging to “lock in” a future-proof design
5. Regional system operators are not yet ready for meshed offshore grids in terms of regulatory (planning, open access) frameworks and market integration

Positive Developments that Facilitate Planned OSW Transmission

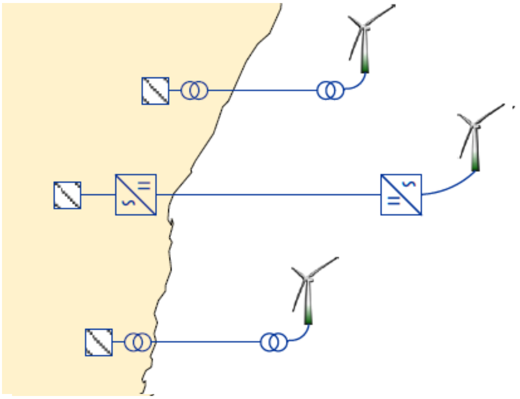
- Size of OSW plants has grown to 1,200-1500+ MW, making individual gen-ties as cost effective as planned HVDC “collector lines” for three to five 300-400 MW wind farms
  - Allows for the design of gen ties that can be integrated into an offshore grid at some point in the future
- States can use OSW generation procurement to specify gen-tie designs and guide generators to interconnect at the most attractive onshore POIs (including shared POIs)
  - NYSERDA’s procurement requiring HVDC gen ties and mesh-ready offshore substations
- Evolving generation interconnection and transmission planning processes are slowly getting better at identifying the best onshore POIs and OSW transmission solutions
  - PJM’s State Agreement Approach (SAA) to interconnect 7,500 MW of New Jersey OSW generation (with cost of onshore upgrades 100% allocated to NJ, irrespective of benefits to other states, if any)
  - FERC NOPRs on (1) regional transmission planning and cost allocation and (2) generation interconnection
- Limited congestion within grid operators (e.g., ISO-NE, PJM) makes implementation of a fully meshed offshore grid (links between offshore substations) less urgent in the near term
- HVDC technology standards are starting to emerge (e.g., 525kV HVDC; DC circuit breakers)

Contents

Offshore Transmission Concepts: Radial vs. Networked

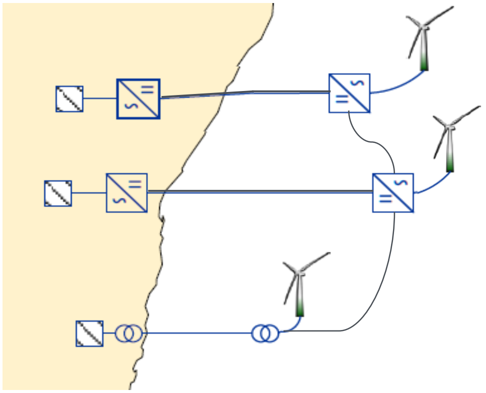
Radial Tie Lines

Transmission links bundled with individual OSW plants



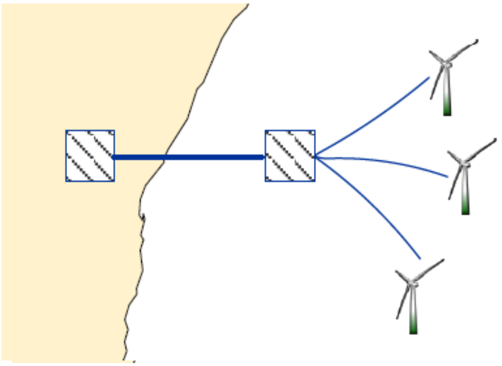
Meshed Generation Ties

Individual tie lines to shore linked through offshore transmission



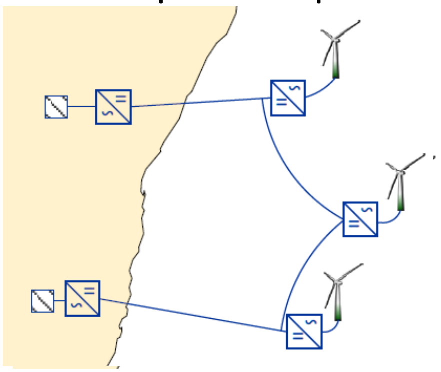
Shared Collector Station

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 development
- Planned OSW transmission allows for the long-term optimization of offshore and onshore transmission, in particular POIs
  - Mitigates environmental impacts and reduces overall cost of generation, offshore transmission, and onshore upgrades

Gen-ties vs. Planned OSW Transmission Solutions

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

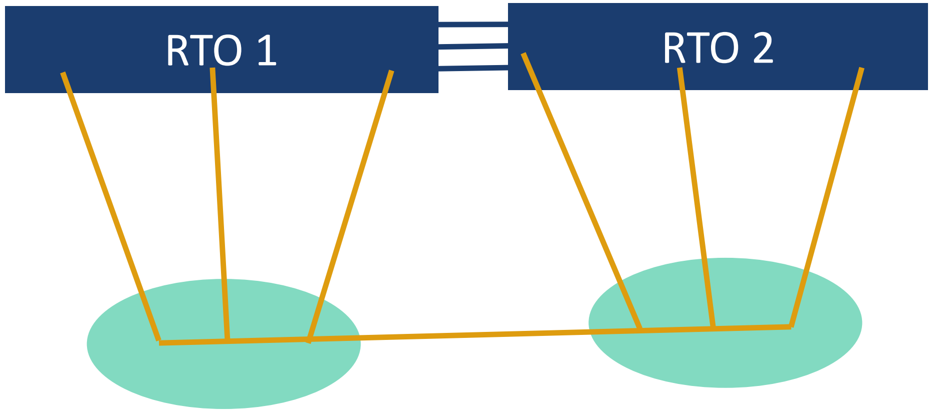
- Modest total development and small incremental steps
  - 400 MW per HVAC circuit only
- Modest distance from shore
  - Ideally less than 40 miles
- Many landing points with robust on-shore transmission
  - Requires 3 HVAC circuits for every 1,200 MW of total OSW development
- Long distances between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

Factors favoring planned offshore grids for large-scale wind plants with HVDC links

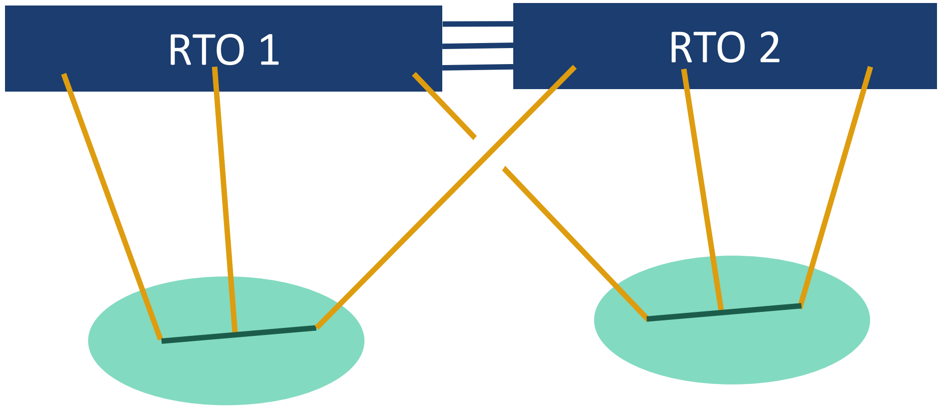
- Large size of total wind generation commitment with sizable procurement steps
  - 1,200-1,600 MW per HVDC circuit
- Several plants close to each other but long distances from shore or from sufficiently-robust onshore transmission nodes
- More efficient use of scarce right-of-way
  - Few landing points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

Offshore Grid Designs and Technology Standards

Conventional Thinking?

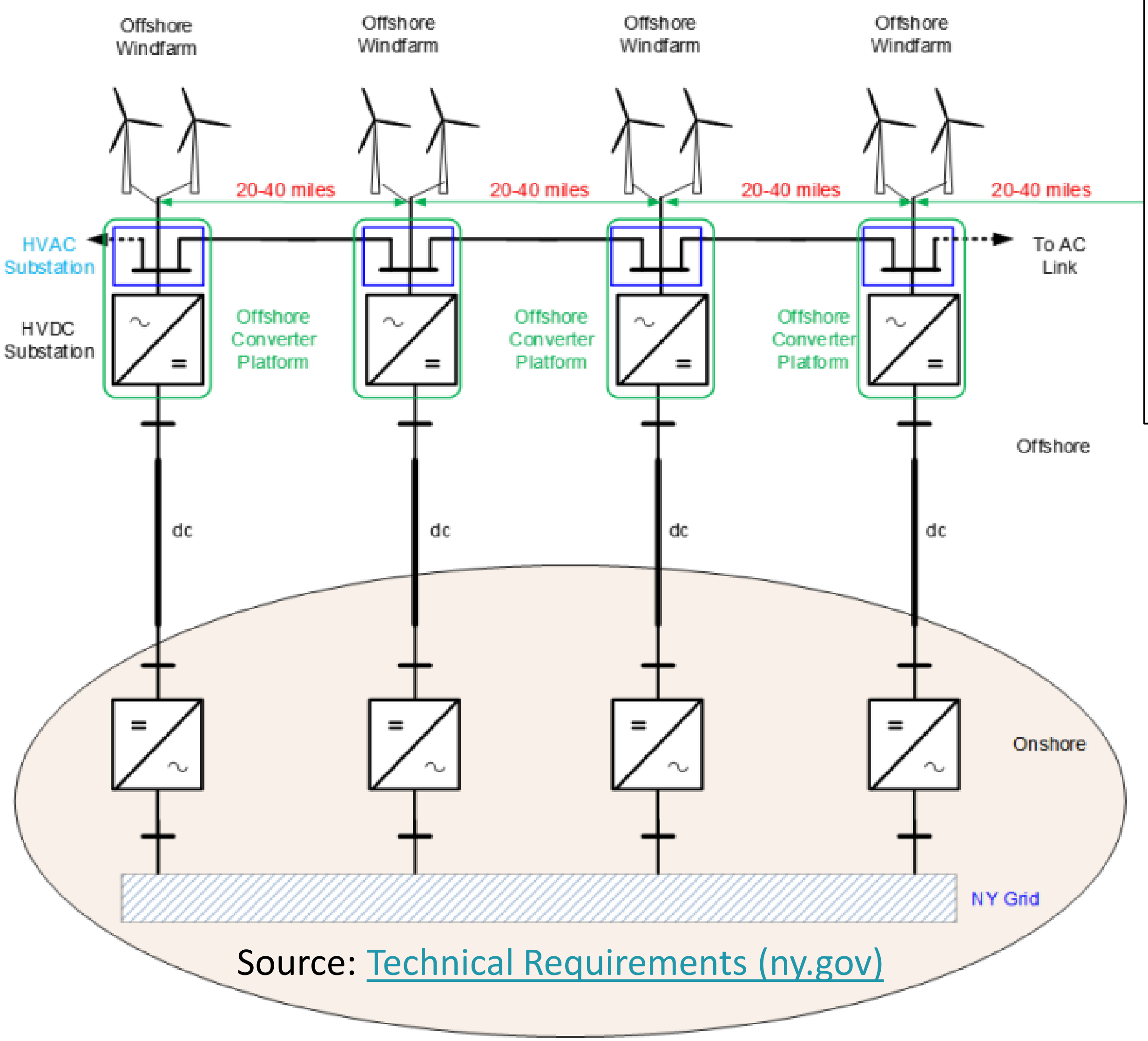


More Effective Alternative?

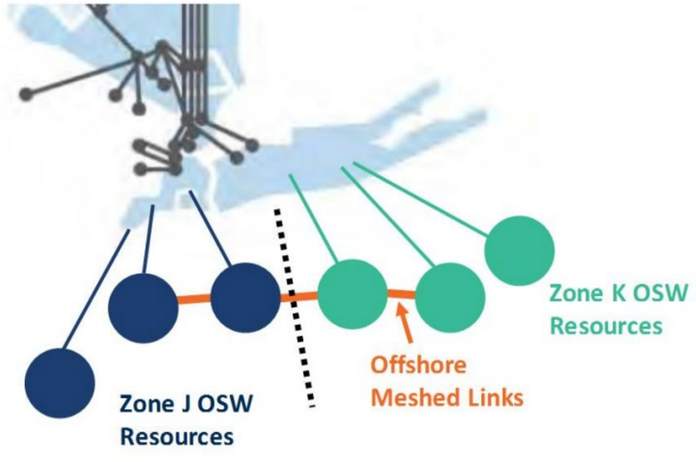


- Many offshore grid designs are possible and will have to be evaluated through proactive, multi-value planning for:
  - Total (not piecemeal) generation interconnection needs
  - Creating cost-effective capability at the POIs in the most attractive grid locations with least environmental impacts
  - Identifying the most beneficial onshore+offshore grid configurations
  - Effective integration of regional and interregional planning
- Technology standards will need to be developed to ensure modularity, compatibility, and inter-operability
  - New 525kV HVDC technology as "standard" going forward?
  - Vendor compatibility requirements?
  - Advanced technology solutions to address onshore injection limits (based on single-largest-contingency)?
  - Mesh-ready, technology-compatible offshore substation design?

NYSERDA: HVDC Gen Ties with Mesh-Ready Substations



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 AC "mesh-ready" offshore HVDC substations adds only approx. $40 million (1%) to the total cost of a 1,200 MW plant
- Mesh-ready offshore substations can be (later) be linked at a cost of $120-240 million per link

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

HVAC or HVDC Links Between Offshore Substations?

HVAC Links – Pros

- Can accommodate all HVDC technologies, vendors, voltage levels
- Allows for mesh-ready standard utilizing common, commercially-available technology
- Cost effective for limited capacity (e.g., two controllable 400 MW links) between near-by OSW plants with HVDC gen ties
- Also provides backup for offshore converter outages (planned and unplanned)

HVAC Links – Cons

- Limited to linking near-by OSW plants (e.g., in same lease areas)
- Lower capacity of links does not allow for full backbone design
- High losses for transfers between POIs

HVDC Links – Pros

- Allows for long, 1200+ MW offshore links (valuable if large, low-loss transfers between onshore POIs are needed)
- Allows for multi-terminal backbone design

HVDC Links – Current Cons

- Requires same voltage level for all elements; different vendors not yet compatible
- Does not provide backup for offshore converter outages
- Requires HVDC breakers, which still have limited commercial availability, uncertain costs, and have not yet been deployed in offshore locations
- High-capacity transfers between OSW plants may have limited value

Contents

Improved Grid Planning is Urgently Needed

Improve RTO generation interconnection and transmission planning processes:

– Adapt GI process to pro-actively identify best onshore POIs for known OSW interconnection needs of current rounds of state procurements
  - Pre-planned POIs for necessary total OSW capacity that minimize onshore upgrades and environmental footprint (e.g., PJM's New Jersey SAA)
  - Fast-track (or skip) existing GI process for OSW generation assigned to these POIs

– Implement pro-active long-term, scenario-based planning process for all future transmission needs (reliability, market efficiency, public policy), for OSW developments beyond 2030
  - Implement FERC NOPRs on regional transmission planning and generation interconnection
  - Shift from using GI process to rely more on proactive transmission planning processes (e.g., SPP ITP, MISO MVP)
  - <u>Note</u>: improved planning processes will take years to implement → transmission not ready for 10-15 years

– More actively "plan" offshore transmission between regions and across regional seams
  - Current interregional coordination process ineffective; little active interregional planning despite many national studies showing significant net benefits of expanded transfer capabilities
  - Limited but successful model: SPP-MISO Joint Transmission Interconnection Queue (JTIQ) Study

Implement Pragmatic Cost Allocations

New, less-contentious cost-allocation approaches are needed to achieve efficient OSW transmission solutions. More cost-effective solutions will facilitate cost allocation!

- Reduce generator responsibility for distant network upgrades identified through today's generation interconnection process
  - Focus generator allocations initially on upgrades needed locally for non-firm interconnection rights
- Address network upgrades through transmission planning process, with cost allocation that roughly reflects beneficiaries
  - If network upgrades are mostly driven by states' public policy needs, consider allocating costs to the respective states (in exchange for clean-energy interconnection rights)
  - Without clean-energy interconnection rights, consider allocating costs to benefitting loads and, pro-rata, to interconnecting generators (similar to CAISO's Tehachapi approach and SPP-MISO's JTIQ)
- Implement portfolio-based (not project-specific) cost allocations
  - Less controversial and easier to implement because portfolio-wide benefits tend to be more even distributed and more stable over time
- Avoid cost allocations that are strictly based on quantified benefits (which change over time, and across scenario assumptions and benefit metrics)

Open-Access Provisions and Market-Operations Needs

- Develop contracting provisions and open-access regulations that allow for shift to multi-user, multi-POI transmission for OSW generation
  - Priority rights for directly-interconnected generators?
  - Regulated regional transmission preferable over (challenging) merchant transmission models?
- Improve RTO market design so it can efficiently use HVDC capability within/between regions
  - RTOs are yet not able to optimize flow over internal HVDC lines (along with SCED generation dispatch) in their day-ahead and real-time markets
  - The capability of existing interregional HVDC lines remains poorly utilized
    - Example: PJM IMM reports real-time flows over merchant HVDC links between PJM and NYISO in the wrong direction (from high to low prices) during 40% of the year
- Also consider:
  - Make clear and more predictable BOEM permitting for third-party offshore transmission
  - Make tax credits available for third-party transmission contracts serving offshore wind generation (to level playing field between generator-owned gen-ties a and independent transmission)

Contents

Summary of Recommendations

Developing well-planned, cost-effective transmission for OSW will likely require:

1. Improve <u>transmission planning</u> processes to pro-actively develop longer-term onshore+offshore grid solutions that reduce total costs and are:
   - Modular and expandable to align transmission investments with generation procurements and development timelines
   - “Future proof” (compatible with technological developments)
2. In the meantime, proactively develop onshore POIs (that can accommodate HVDC capabilities and mitigate permitting risks and environmental impacts) for full amount of existing OSW generation commitments
3. Develop <u>technology and design standards</u> that ensure scalability and compatibility of transmission solutions over time
   - Consider procurements that based on “mesh-ready” offshore substation designs that can accommodate both HVAC and HVDC links (so they can to be integrated into a meshed offshore grid at some point in the future)
   - Allow for advanced technology solutions to address “single-largest contingency” limits

Summary of Recommendations (cont'd)

Developing well-planned, cost-effective transmission for OSW will likely require:

4. Develop contracts and regulations that:
   - Mitigate project-on-project and supply-chain risks
   - Provide for open-access transmission and POI flexibility for OSW generators
   - Facilitate onshore+offshore grid optimization and market integration of offshore capabilities
5. Improve RTO market design and market operations to take full advantage of HVDC technologies within regions and across market seams
6. Streamline BOEM transmission-only permitting
7. <u>Tax credits</u> that can be applied to contractual structures for third-party transmission serving offshore wind generation

About the Speaker

Johannes P. Pfeifenberger

PRINCIPAL
BOSTON

Hannes.pfeifenberger@brattle.com

+1.617.234.5624

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 matters in SPP, MISO, PJM, New York, New England, ERCOT, CAISO, WECC, and Canada.

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.

Brattle Reports on Transmission Planning


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

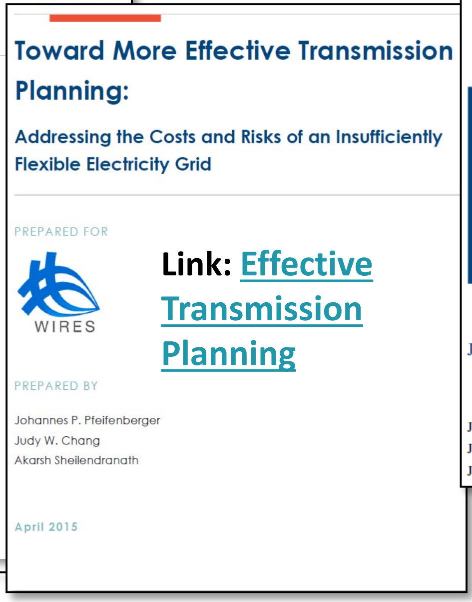
PREPARED FOR
WIRES

PREPARED BY
Judy W. Chang
Johannes P. Pfeifenberger

May 2016

THE Brattle GROUP

Link: Well-Planned Transmission

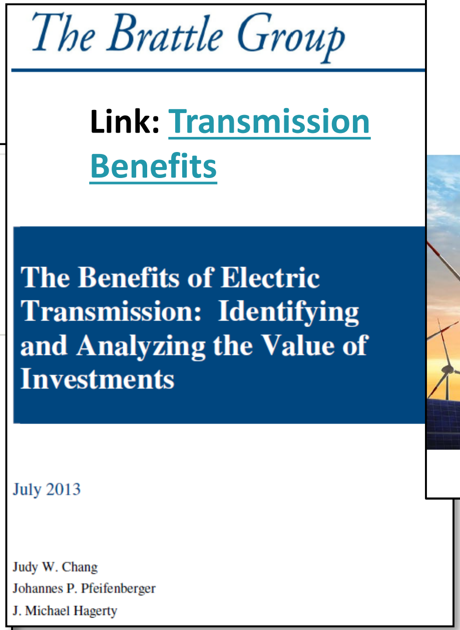

Toward More Effective Transmission Planning:
Addressing the Costs and Risks of an Insufficiently Flexible Electricity Grid

PREPARED FOR
WIRES

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

April 2015

Link: Effective Transmission Planning

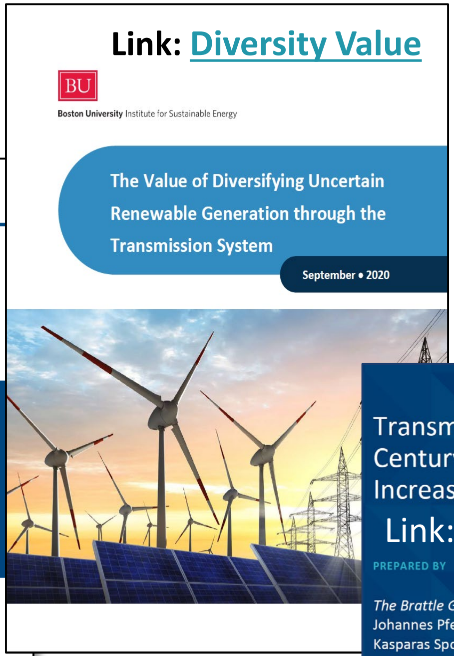

The Brattle Group

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

July 2013

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

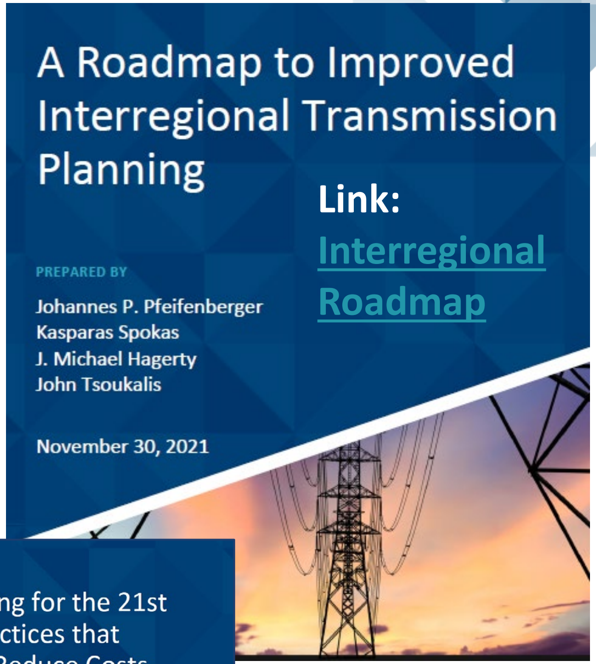
Link: Transmission Benefits


BU
Boston University Institute for Sustainable Energy

The Value of Diversifying Uncertain Renewable Generation through the Transmission System

September • 2020

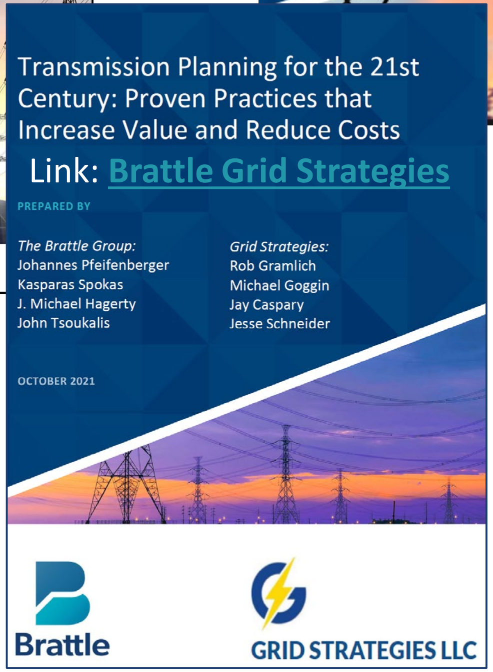
Link: Diversity Value


A Roadmap to Improved Interregional Transmission Planning

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

November 30, 2021

Link: Interregional Roadmap


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

PREPARED BY

The Brattle Group:
Johannes Pfeifenberger
Kasparas Spokas
J. Michael Hagerty
John Tsoukalis

Grid Strategies:
Rob Gramlich
Michael Goggin
Jay Caspary
Jesse Schneider

OCTOBER 2021

Brattle
GRID STRATEGIES LLC

Link: Brattle Grid Strategies

Summarizes proven approaches to quantifying various benefits

Additional Reading on Transmission

Pfeifenberger, Generation Interconnection and Transmission Planning, Presented at ESIG Special Topic Workshop, August 9, 2022.

Pfeifenberger, Proactive, Scenario-Based, Multi-Value Transmission Planning, Presented at PJM Long-Term Transmission Planning Workshop, June 7, 2022.

Pfeifenberger, Planning for Generation Interconnection, Presented at ESIG Special Topic Webinar: Interconnection Study Criteria, May 31, 2022.

RENEW Northeast, A Transmission Blueprint for New England, Prepared with Borea and The Brattle Group, May 25, 2022.

Pfeifenberger, New York State and Regional Transmission Planning for Offshore Wind Generation, NYSERDA Offshore Wind Webinar, March 30, 2022.

Pfeifenberger, The Benefits of Interregional Transmission: Grid Planning for the 21st Century, US DOE National Transmission Planning Study Webinar, March 15, 2022.

Pfeifenberger, 21st Century Transmission Planning: Benefits Quantification and Cost Allocation, Prepared for the NARUC members of the Joint Federal-State Task Force on Electric Transmission, January 19, 2022.

Pfeifenberger, Spokas, Hagerty, Tsoukalis, A Roadmap to Improved Interregional Transmission Planning, November 30, 2021.

Pfeifenberger, Tsoukalis, Newell, "The Benefit and Cost of Preserving the Option to Create a Meshed Offshore Grid for New York," Prepared for NYSERDA with Siemens and Hatch, November 9, 2022.

Pfeifenberger, Transmission–The Great Enabler: Recognizing Multiple Benefits in Transmission Planning, ESIG, October 28, 2021.

Pfeifenberger et al., Transmission Planning for the 21st Century: Proven Practices that Increase Value and Reduce Costs, Brattle-Grid Strategies, October 2021.

Pfeifenberger et al., Initial Report on the New York Power Grid Study, prepared for NYPSC, January 19, 2021.

Pfeifenberger, Ruiz, Van Horn, "The Value of Diversifying Uncertain Renewable Generation through the Transmission System," BU-ISE, October 14, 2020.

Pfeifenberger, Newell, Graf and Spokas, "Offshore Wind Transmission: An Analysis of Options for New York", prepared for Anbaric, August 2020.

Pfeifenberger, Newell, and Graf, "Offshore Transmission in New England: The Benefits of a Better-Planned Grid," prepared for Anbaric, May 2020.

Tsuchida and Ruiz, "Innovation in Transmission Operation with Advanced Technologies," T&D World, December 19, 2019.

Pfeifenberger, "Cost Savings Offered by Competition in Electric Transmission," Power Markets Today Webinar, December 11, 2019.

Chang, Pfeifenberger, Sheilendranath, Hagerty, Levin, and Jiang, "Cost Savings Offered by Competition in Electric Transmission: Experience to Date and the Potential for Additional Customer Value," April 2019. "Response to Concentric Energy Advisors' Report on Competitive Transmission," August 2019.

Ruiz, "Transmission Topology Optimization: Application in Operations, Markets, and Planning Decision Making," May 2019.

Chang and Pfeifenberger, "Well-Planned Electric Transmission Saves Customer Costs: Improved Transmission Planning is Key to the Transition to a Carbon-Constrained Future," WIRES and The Brattle Group, June 2016.

Newell et al. "Benefit-Cost Analysis of Proposed New York AC Transmission Upgrades," on behalf of NYISO and DPS Staff, September 15, 2015.

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.

Chang, Pfeifenberger, Hagerty, "The Benefits of Electric Transmission: Identifying and Analyzing the Value of Investments," on behalf of WIRES, July 2013.

Chang, Pfeifenberger, Newell, Tsuchida, Hagerty, "Recommendations for Enhancing ERCOT's Long-Term Transmission Planning Process," October 2013.

Pfeifenberger and Hou, "Seams Cost Allocation: A Flexible Framework to Support Interregional Transmission Planning," on behalf of SPP, April 2012.

Pfeifenberger, Hou, "Employment and Economic Benefits of Transmission Infrastructure Investment in the U.S. and Canada," on behalf of WIRES, May 2011.

Brattle Group Practices and Industries

ENERGY & UTILITIES

- Competition & Market Manipulation
- Distributed Energy Resources
- Electric Transmission
- Electricity Market Modeling & Resource Planning
- Electrification & Growth Opportunities
- Energy Litigation
- Energy Storage
- Environmental Policy, Planning and Compliance
- Finance and Ratemaking
- Gas/Electric Coordination
- Market Design
- Natural Gas & Petroleum
- Nuclear
- Renewable & Alternative Energy

LITIGATION

- Accounting
- Analysis of Market Manipulation
- Antitrust/Competition
- Bankruptcy & Restructuring
- Big Data & Document Analytics
- Commercial Damages
- Environmental Litigation & Regulation
- Intellectual Property
- International Arbitration
- International Trade
- Labor & Employment
- Mergers & Acquisitions Litigation
- Product Liability
- Securities & Finance
- Tax Controversy & Transfer Pricing
- Valuation
- White Collar Investigations & Litigation

INDUSTRIES

- Electric Power
- Financial Institutions
- Infrastructure
- Natural Gas & Petroleum
- Pharmaceuticals & Medical Devices
- Telecommunications, Internet, and Media
- Transportation
- Water

Our Offices


BOSTON


BRUSSELS


CHICAGO


LONDON


MADRID


NEW YORK


ROME


SAN FRANCISCO


SYDNEY


TORONTO


WASHINGTON, DC