New York Power Grid Study and Regional Challenges

PRESENTED BY

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Brattle

Note

This presentation represents the view of the author and does not represent the opinion of NYSERDA, DPS, Pterra, or other Brattle Group staff or clients.

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http://documents.dps.ny.gov/public/MatterManagement/MatterFilingItem.aspx?FilingSeq=259215&MatterSeq=62480

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New York Power Grid Study – Background

New York's Climate Leadership and Community Protection Act (CLCPA)requires:

- 70% renewable generation by 2030
- Zero-emission electricity by 2040
- 85% economy-wide reduction in greenhouse gas emissions by 2050

The CLCPA also specifies minimum amounts of certain types of resources including:

- 6,000 MW of distributed solar resources by 2025
- 3,000 MW of storage by 2030
- 9,000 MW of offshore wind (OSW) generation by 2035
- Much more renewable generation is necessary to achieve the 2040 and 2050 mandates

Meeting these milestones will require significant investments in:

- Renewable generation, storage, energy efficiency measures
- Electrification of the transportation and heating sectors
- Electric transmission and distribution (T&D) infrastructure

New York Power Grid Study – Scope

To meet state policy directives, the PSC, through the Department of Public Service and in consultation with NYSERDA, initiated the **New York Power Grid Study (PGS),** which consists of **three component studies:**

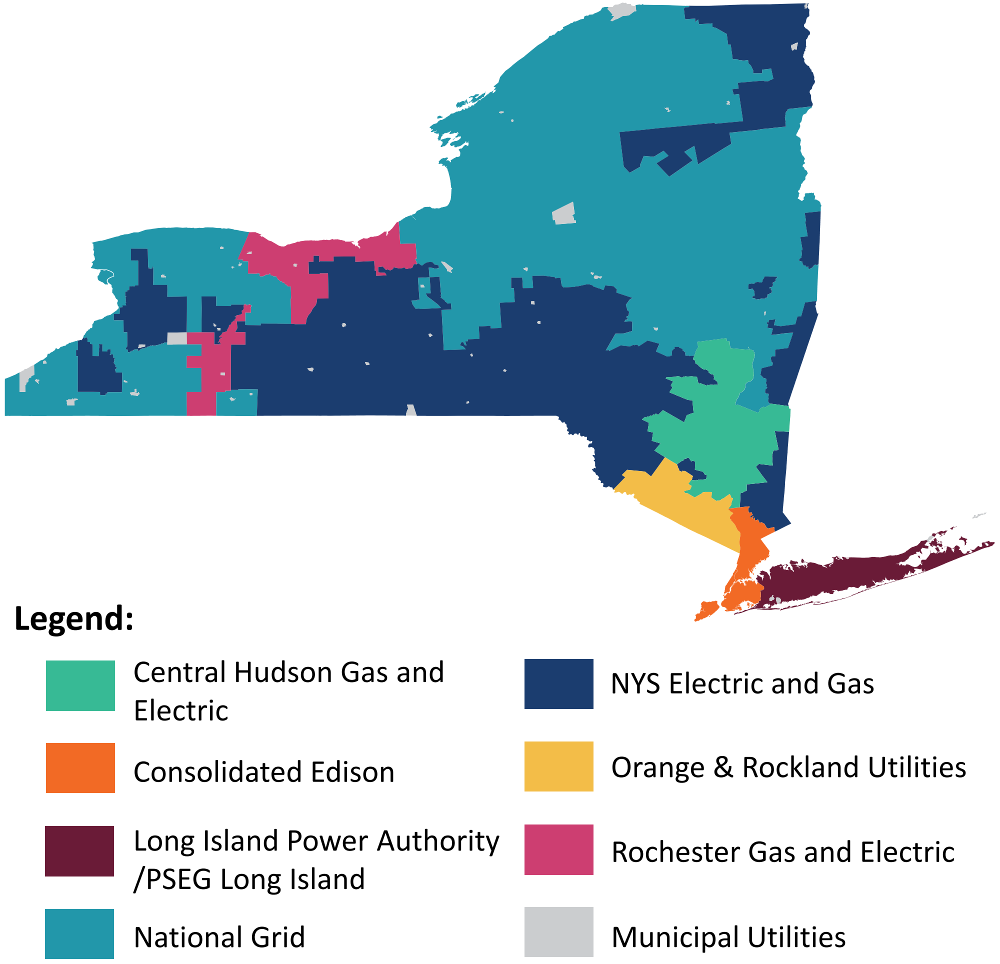
- **Utility Study**: Conducted by the Joint Utilities on local transmission and distribution (LT&D) needs;
- **Offshore Wind (OSW) Study**: Study of offshore and onshore bulk-power transmission scenarios to illustrate possible solutions to integrate the mandated 9,000 MW of offshore wind
  - Conducted by DNV-GL, PowerGem, and WSP for NYSERDA
- **Zero Emissions Study:** Scenario-based study to analyze transmission, generation, and storage options for achieving 70% renewable generation by 2030 and a zero emissions grid by 2040
  - Conducted by Siemens for NYSERDA

Utility Study

New York's utilities undertook a joint study, filed in November 2020, to identify local transmission and distribution (LT&D) upgrades necessary to achieve 70% renewable generation by 2030

- **Phase 1** LT&D projects for PSC approval to address existing reliability needs also provide CLCPA benefits
  - Local transmission projects to unbottle **6.6 GW** of renewable generation
  - Distribution projects to unbottle **2.0 GW** of renewables
- **Phase 2** LT&D proposals for further evaluation, including with new CLCPA benefit-cost analysis (BCA)
  - Local transmission projects would provide **12.7 GW** of additional renewable-integration headroom benefits
  - Distribution projects would support **2.8-4.3 GW** of additional renewable integration headroom benefits

New York State Electric Utility Territories



Utility Study: Local Transmission Takeaways

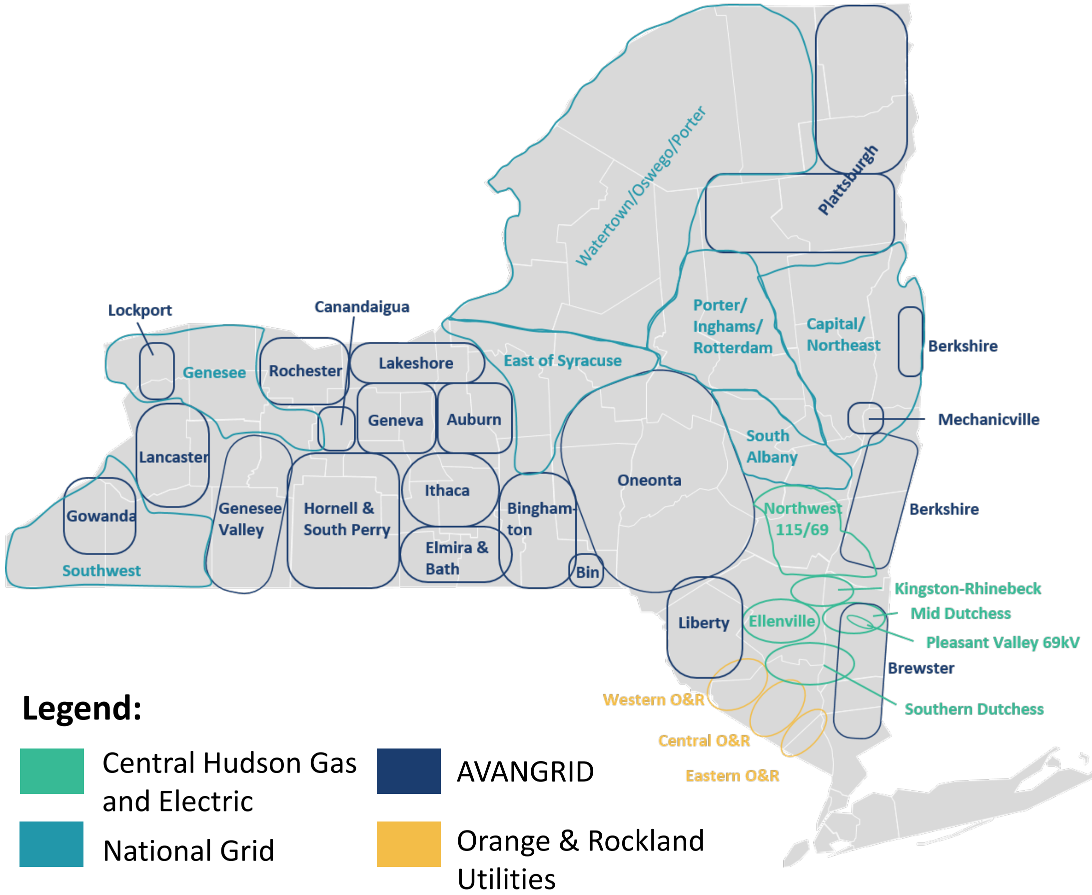
The total LT&D headroom created by the proposed Phase 1 projects appears sufficient to support the integration of land-based renewable resources needed to meet the State's 2030 objective. However:

- The headroom created by Phase 1 projects <u>does not</u> adequately address specific local transmission needs in certain attractive renewable development areas

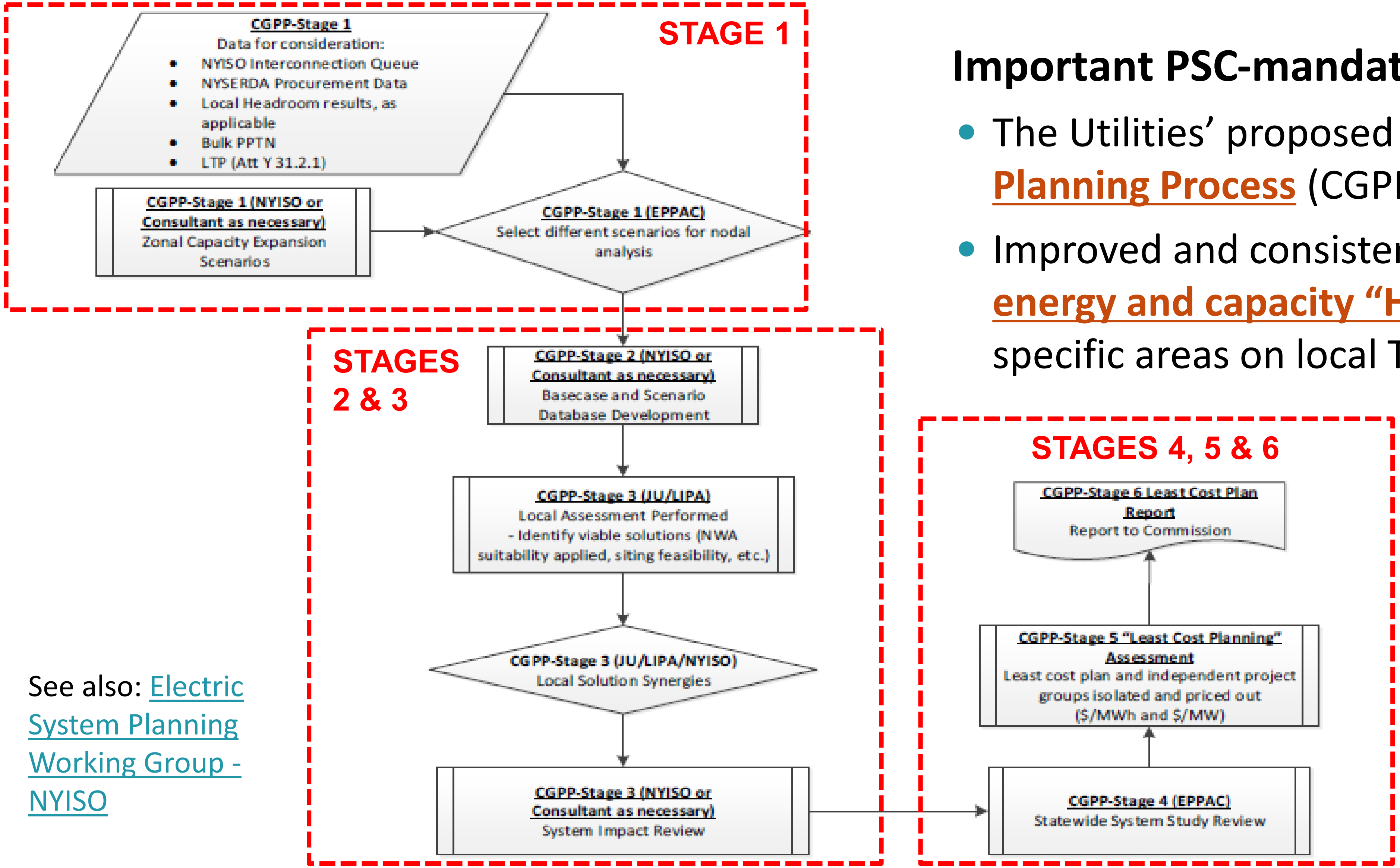
PGS Study recommendations:

- Consider approval of Phase 1 projects
- Accelerate some Phase 1 projects and develop priority Phase 2 projects for attractive renewable locations (**Hornell, Watertown/Oswego/Porter, Genese/Lockport/Lancaster, Central Hudson**)
- Consider developing local <u>**renewable energy zones**</u> (REZs)
- Accelerate implementation of <u>**advanced technologies**</u>
- <u>**Improve planning framework**</u> for Phase 2 projects

Local Transmission Areas in Upstate Utilities' Service Territories



PSC Initiatives: Headroom Determination and Coordinated Planning



Important PSC-mandated initiatives:

- The Utilities' proposed **Coordinated Grid Planning Process** (CGPP) (as shown)
- Improved and consistent determination of **energy and capacity "Headroom"** for specific areas on local T&D grid

See also: Electric System Planning Working Group - NYISO

Advanced Grid Technologies: Making Transmission More Valuable

Advanced, grid-enhancing transmission (GET) technologies can significantly increase the capability of the existing grid, offer low-cost solutions to address reliability needs, and make new transmission more valuable and cost effective … but the technologies need to be deployed more quickly

- Chapter III of NY Power Grid Study: Increasingly well-tested and commercially-applied technologies include: dynamic line rating, smart wires and flow control devices, grid-optimized storage, and topology optimization
- See also Brattle case study in SPP: DLR, topology optimization, and advanced power-flow controls can integrate 2,670 MW of renewable generation for $90 million
- Value proposition: more visibility of actual grid capability; shift flows to underutilized portions of the grid

FERC NOPRs: Consideration of GETs needs to be expanded beyond addressing operational and seam-related reliability and congestion needs – and be part of available solutions to address both transmission planning and generation interconnection needs

- As low-cost solutions to address reliability needs identified in generation interconnection and near-term planning
- In long-term multi-value planning to make new transmission more cost effective and valuable, reducing system-wide costs

Offshore Wind Study

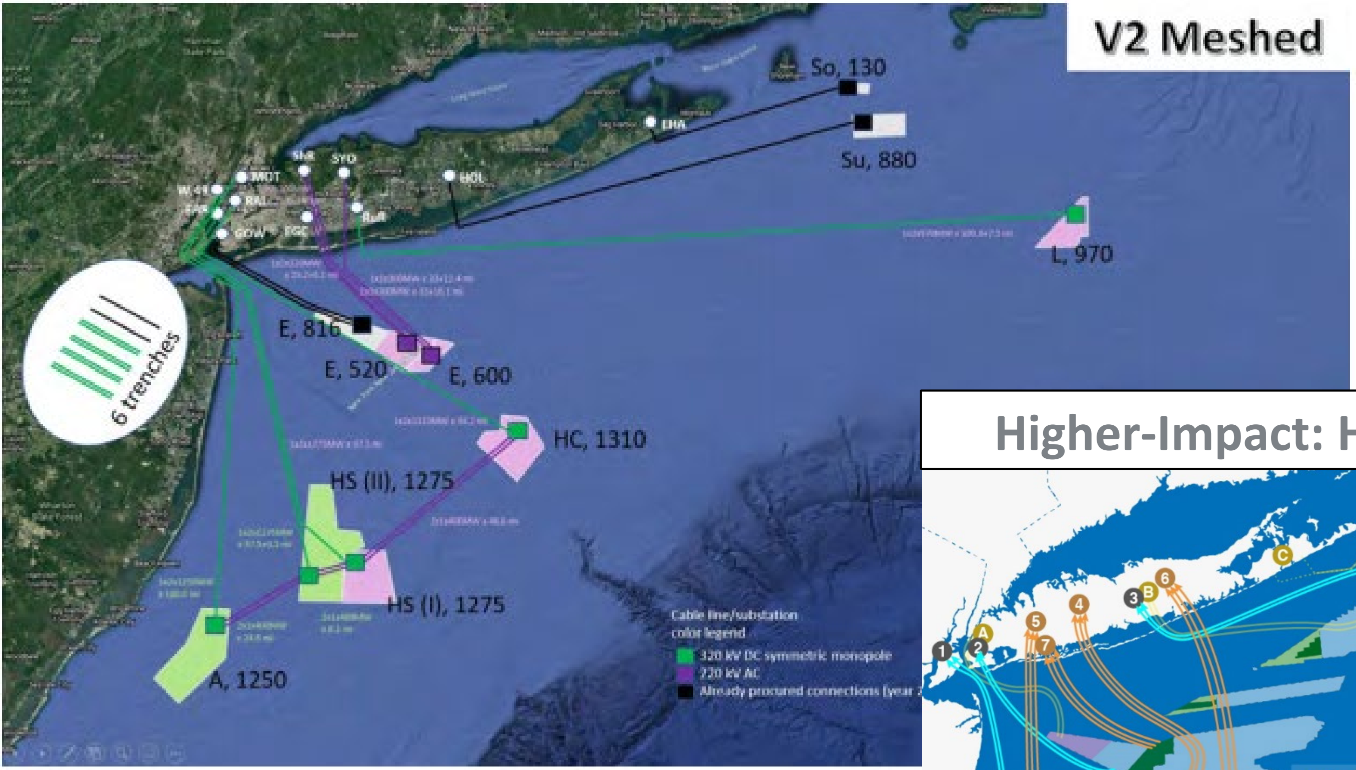
The Offshore Wind Integration Study (OSW Study) assesses bulk transmission needs relating to the integration of 9,000 MW (9 GW) of offshore-wind generation by 2035

- "**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 GW of OSW is feasible without major near-term bulk transmission upgrades if: 5-7 GW of OSW can be routed into NYC (so only 2-4 GW would need to connect to the grid on L.I.)
  - New transmission from Long Island likely needed by 2030-35 (sooner if more OSW connects on L.I.)
  - Significant uncertainty about most-likely and most-feasible POIs (OSW Study vs. related other studies)
- Requires careful planning of OSW procurement, battery deployment, and coordinated permitting
  - May warrant the development of "OSW hubs" to interconnect 5-7 GW in NYC (as proposed in Utility Study)
- Pursue options that allows for the creation of a more flexible and reliable "meshed" offshore grid

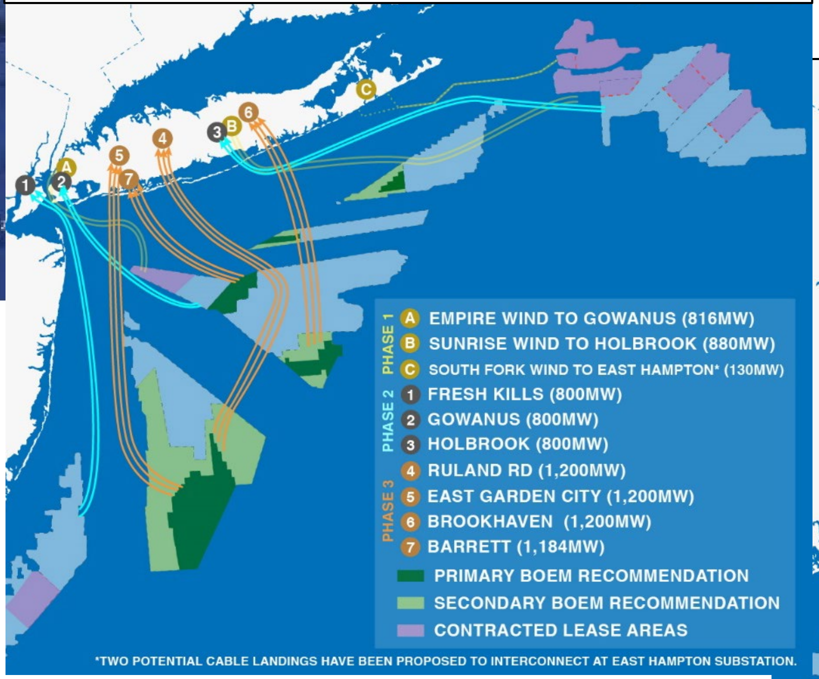
OSW Study vs. Similar Other Studies: Routing and POI Challenges



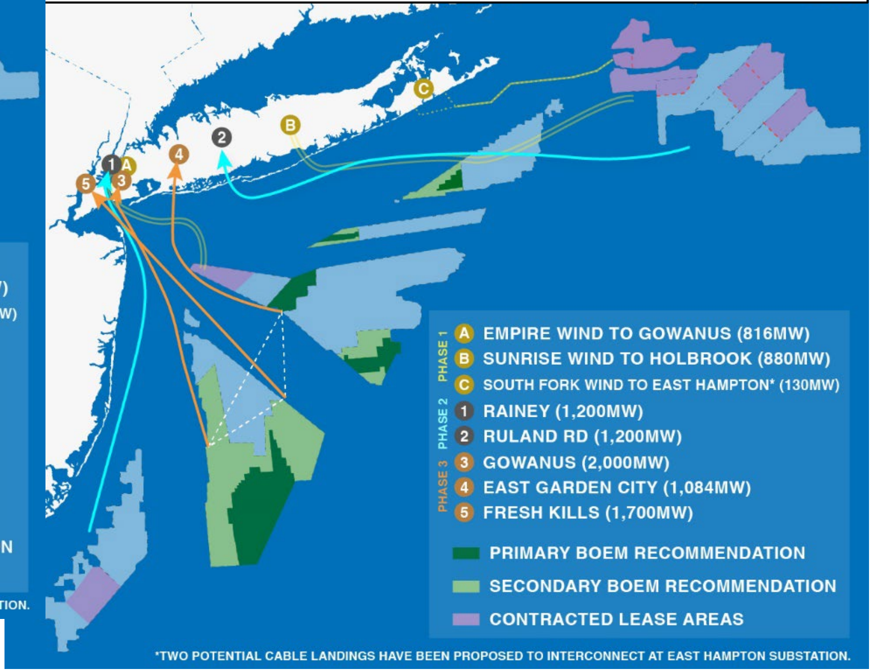
Source: OSW Study

Use of existing/retiring generating plants as points of interconnection: The Beacon Wind project will support the retirement of aging fossil fuel plants in Queens as part of the transition to clean energy; and the Empire Wind project may evolve to potentially support the retirement/repowering of the E.F. Barrett Generation Station in Nassau County

Higher-Impact: HVAC Gen Ties



Lower-Impact: HVDC Gen Ties



Source: Anbaric Study for New York State

NYSERDA Initiative: OSW Cable Corridor Constraints Assessment

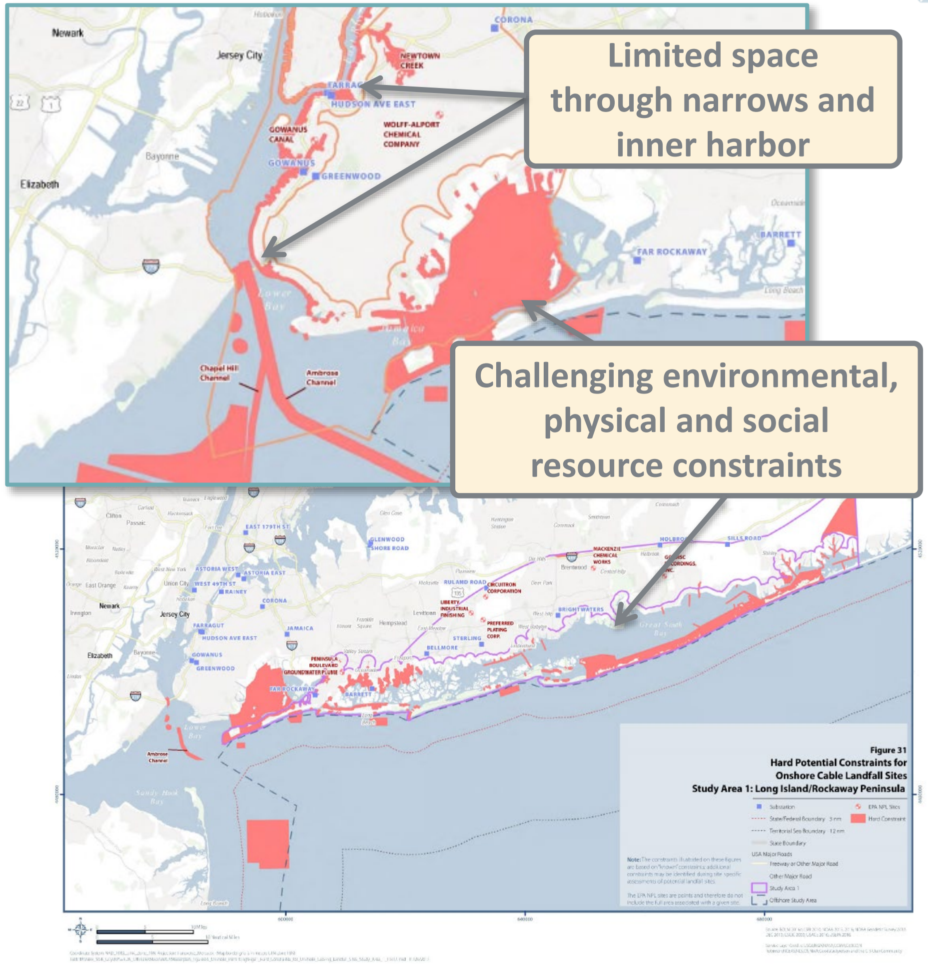
There are a limited number of robust POIs for connecting offshore wind to the onshore grid and limited access routes to these POIs

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, but many constraints exist

NYSERDA's [OSW Cable Corridor Constraints Assessment] to facilitate coordination of routing, permitting and planning (For example, see [NY Offshore Wind: Evaluating Sea-shore (oedigital.com)])

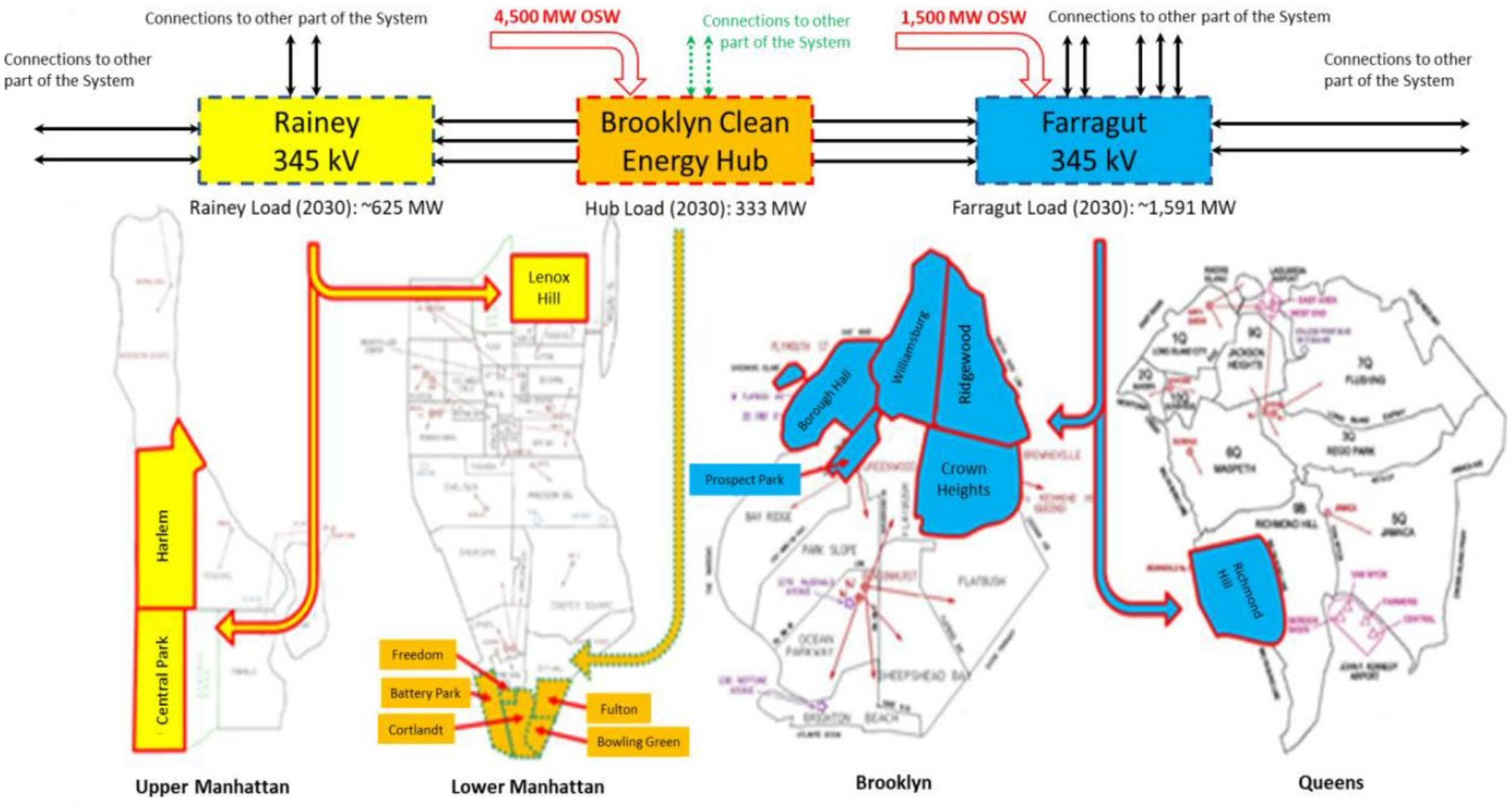
Landing Limitations along NY Coast



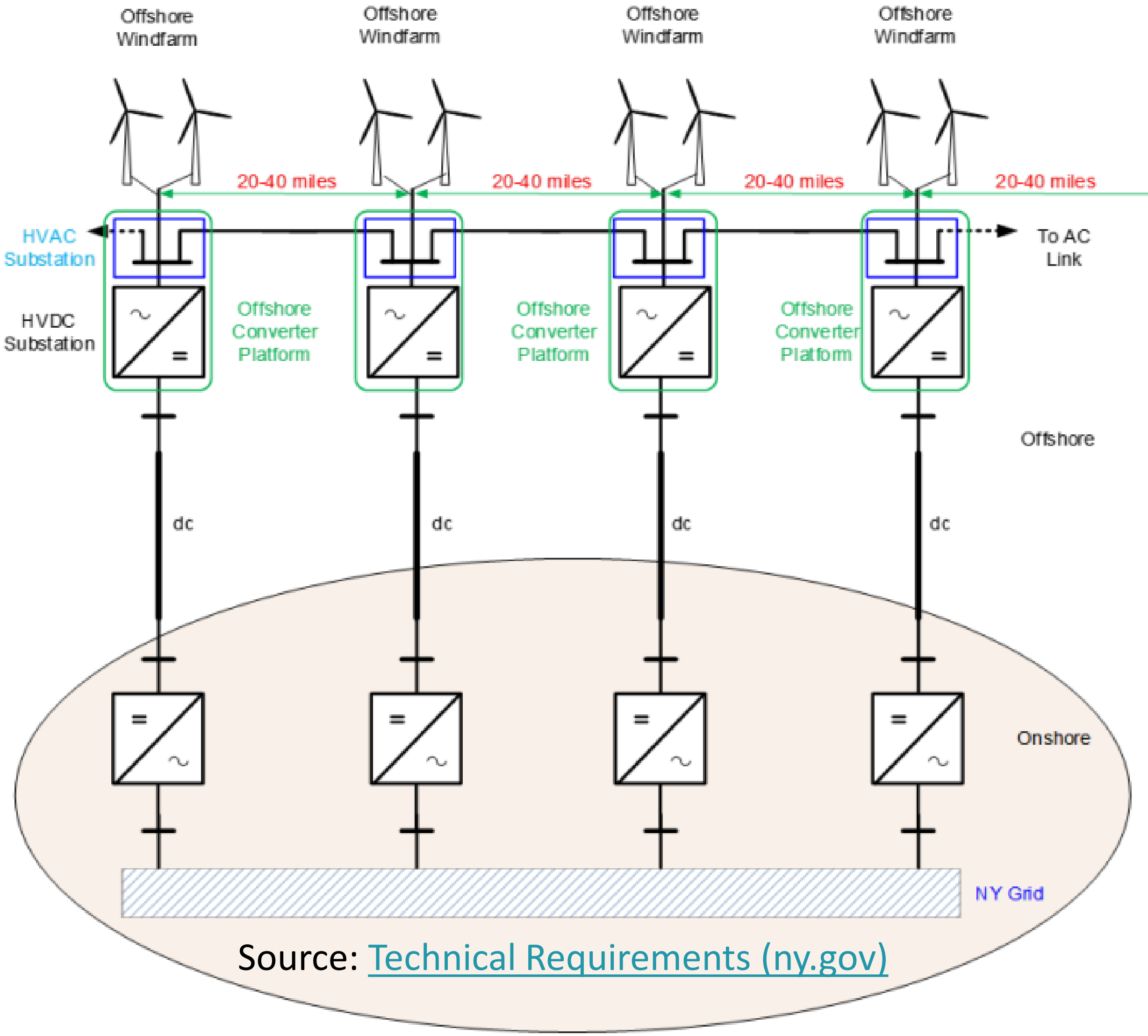
ConEd Energy Hub: Proposal to Address NYC's POI Challenge

In Case 20-E-0197 (transmission planning pursuant to the AREGCB Act), ConEd petitioned for approval of its proposed **Brooklyn Clean Energy Hub**

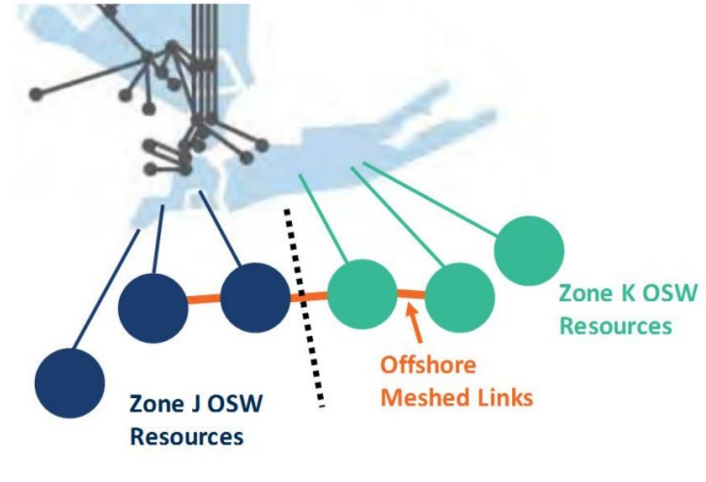
Could integrate up to 6,000 MW of HVAC grid interconnection for OSW generation (e.g., feeds from several separately-located HVDC converter stations)



NYSERDA Initiative: Procure **Mesh-Ready** 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

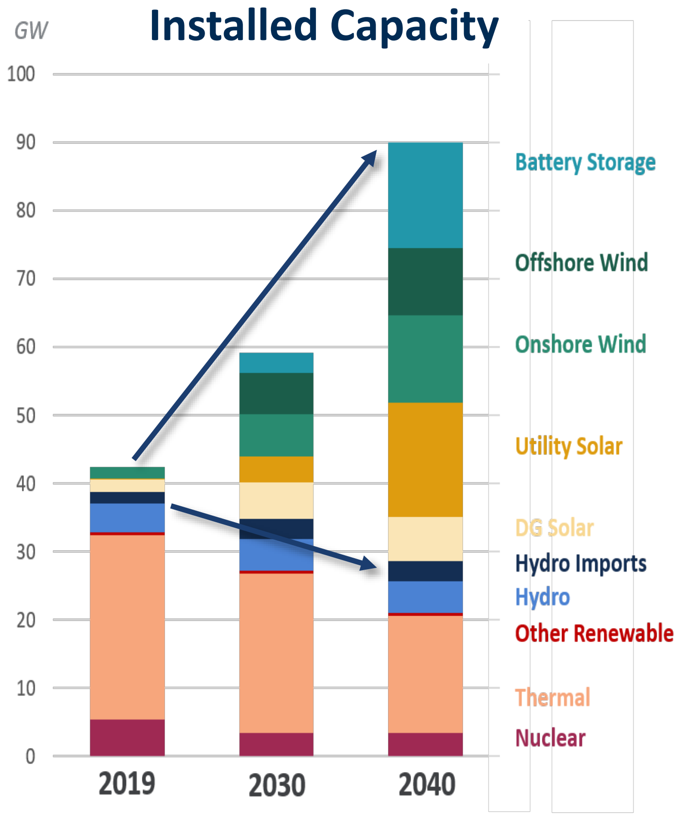
NYSERDA Draft [RFP for 2022 OSW Solicitation] (for at least 2,000 MW) requires each proposal to utilize HVDC technology and meet [mesh-ready standards]

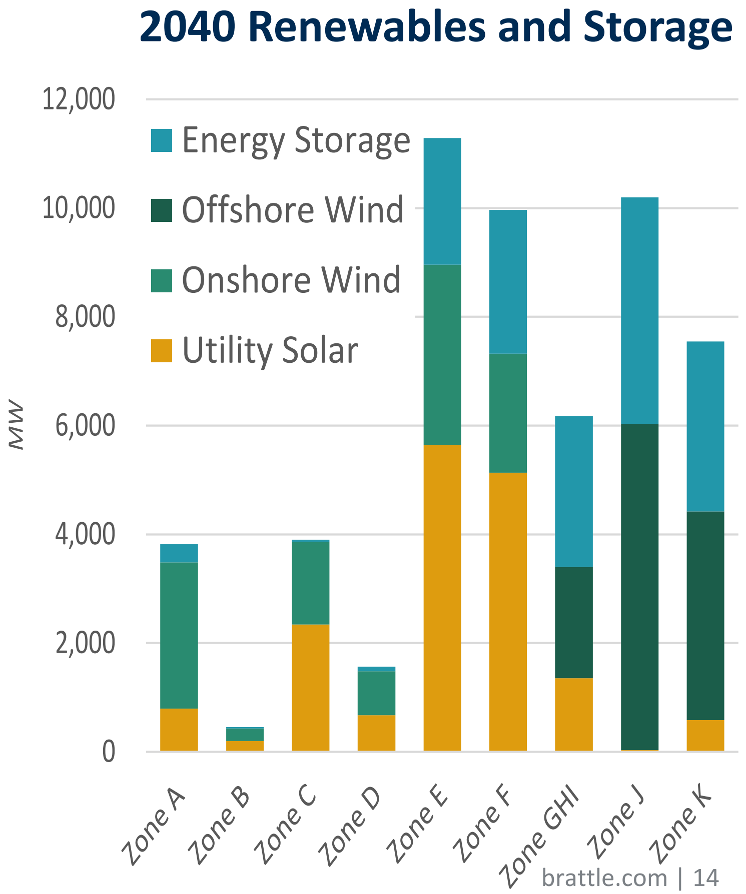
Zero Emissions Study

Analyzes transmission, generation, and storage scenarios for meeting NY's goals of zero-emission electricity by 2040 and 70% renewable generation by 2030 (drawing on New York Decarbonization Pathways Study)

2040 Results:

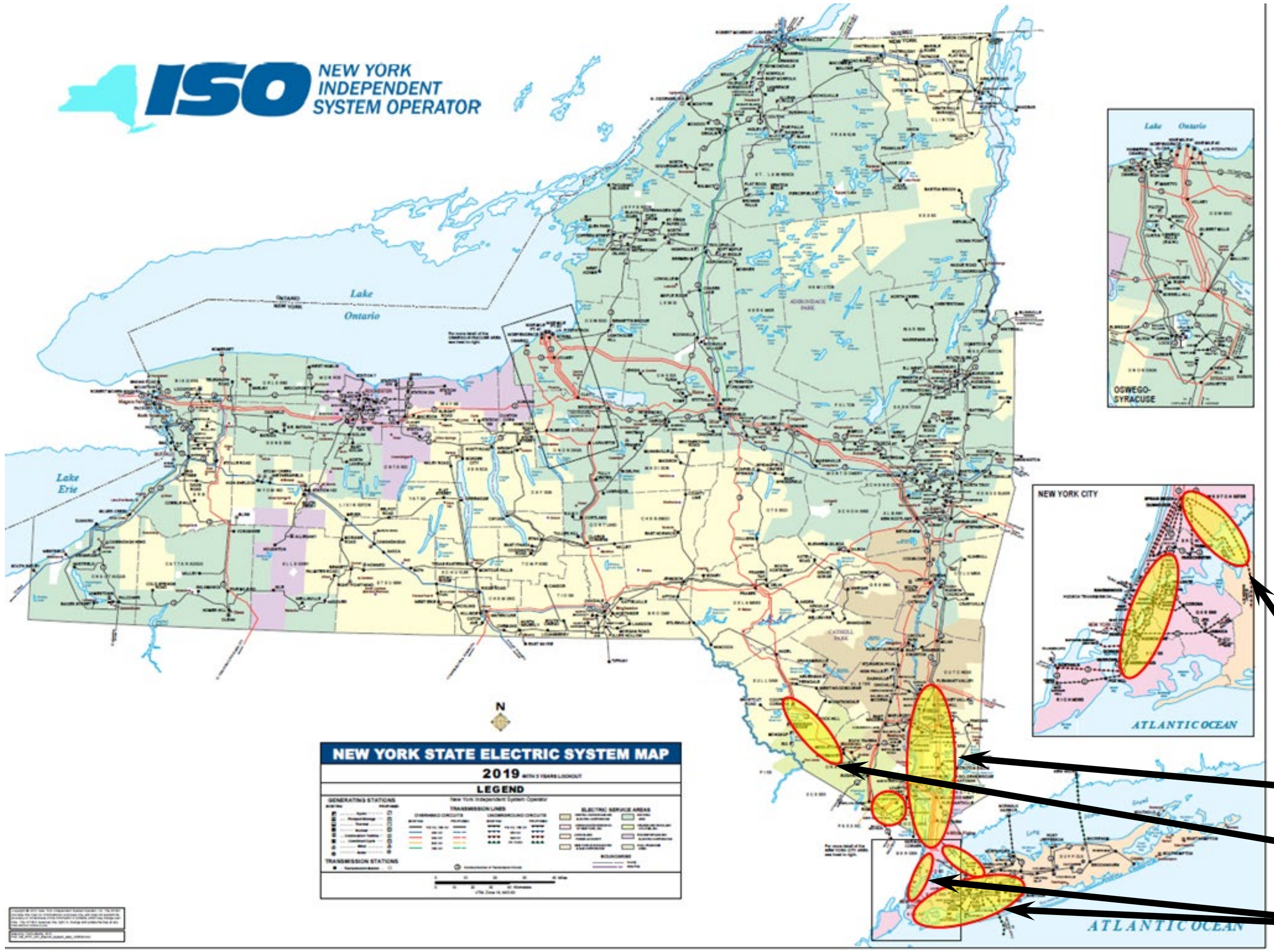
- Installed capacity more than double today's
- 10-15 GW each onshore wind, offshore wind, solar, and storage
- Ideally developed in certain areas:
  - Onshore wind primarily in western and northern NY (NYISO Zones A-F)
  - Offshore wind downstate (I, J, K)
  - Solar in central NY
  - Storage in central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





Zero Emissions Study: Transmission Needs

2040 Projected Congestion Areas



2030 goals can likely be met at low levels of curtailment and congestion without significant bulk-power transmission beyond those already planned and under development

- Contingent on study’s renewable/storage buildout
- Lower-voltage system needs are assessed in NYISO’s CARIS and the Utility Study

- By 2040, high congestion and some curtailments point to <u>the potential for cost-effective bulk transmission upgrades</u>
- High projected 2040 congestion costs can be mitigated cost-effectively with bulk transmission projects in four specific grid locations:
  - at the Dunwoodie to Shore Rd cables
  - at the Millwood South Interface
  - downstream of Coopers Corner into Zone GHI
  - at NYC and west Long Island area

Power Grid Study: Additional Findings & Recommendations

Future NY **transmission needs will depend on** total load and which new resources are developed where over next 20 years—all major uncertainties

- The Zero Emissions Study's renewables and storage investments were optimized to the grid's capabilities but differ from similar other studies (CARIS, E3, Brattle), illustrating uncertainty
- Renewable generation ranges 29-42 GW in 2030, and 53-66 GW in 2040 across studies
- Different load, renewable generation, and battery investment locations will affect grid needs

Achieving the Study's high level of **coordinated development of location-specific renewable generation, storage, and transmission** may be challenging. It requires:

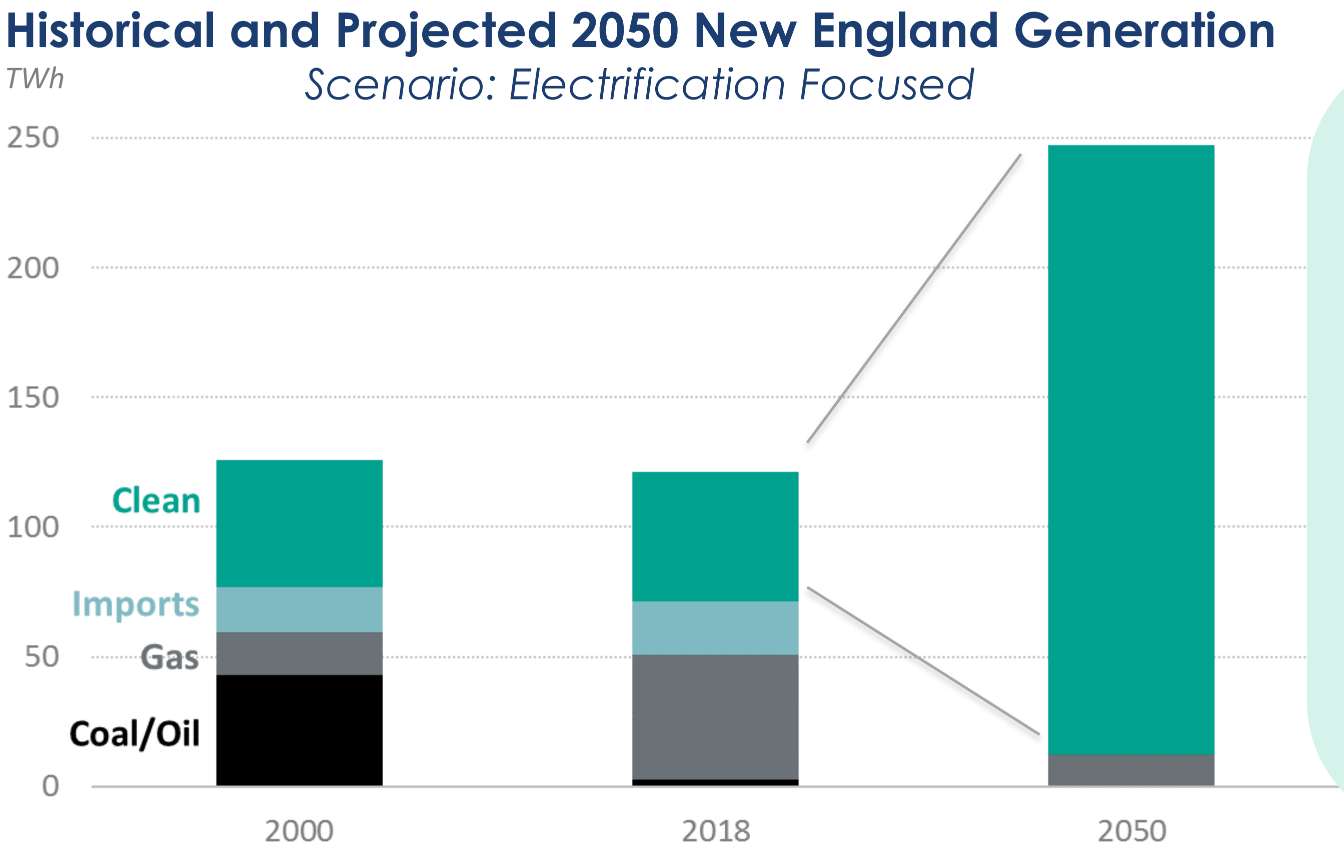
- More <u>coordinated planning</u> for bulk transmission, local transmission, and distribution infrastructure
- Careful planning and contracting for timely and location-specific optimization of <u>storage</u> deployment
- Updating <u>wholesale market rules</u> to support this market evolution (including to allow storage facilities to capture the full value they are assumed to provide in the study)
- Development of retail regulations that support <u>distributed renewable generation and storage</u> and allow for their contribution to wholesale market needs

Power Grid Study: Additional Findings & Recommendations (cont'd)

- Study reflects an optimistic view of congestion, curtailments, operational challenges
  - Significant congestion and curtailments may result from constraints on the lower-voltage transmission (rated at 115/138 kV) and during outages on the bulk transmission system
- Continue to **<u>improve studies and planning processes</u>** to better coordinate NYISO, Utility, and NYSERDA efforts and periodically reassess transmission needs
  - Address <u>OSW-related transmission on/from Long Island</u> and initiate multi-disciplinary planning and coordination to develop cost-effective options for <u>routing up to 6 GW of OSW into NYC</u>
  - Develop more detailed and consistent studies to <u>quantify existing and new headroom</u> in various transmission-constrained areas on both the local and bulk transmission systems
  - Conduct further studies to better understand <u>future generation and long-duration storage</u> technology options available after 2035 to achieve a zero emissions grid by 2040
- NYISO's <u>economic</u> and <u>public-policy</u> planning processes can provide effective mechanisms for identifying bulk needs and developing innovative, integrated solutions

Regional Challenge: New England Clean-Energy Development Need

- Replace about **50% of supply** currently from fossil fuel-fired resources
- Supply the approximately **100% increase in demand** from electrification



Source: ISO-NE, Key Grid and Market Stats, https://www.iso-ne.com/about/key-stats/, accessed June 28, 2019.

Clean-energy additions will have to accellerate 4x-8x over 2030-50:

- Historical additions: 280 MW/yr
- Planned through 2030: 830 MW/yr
- Needed 2030-50: 3,500-6,600 MW/yr

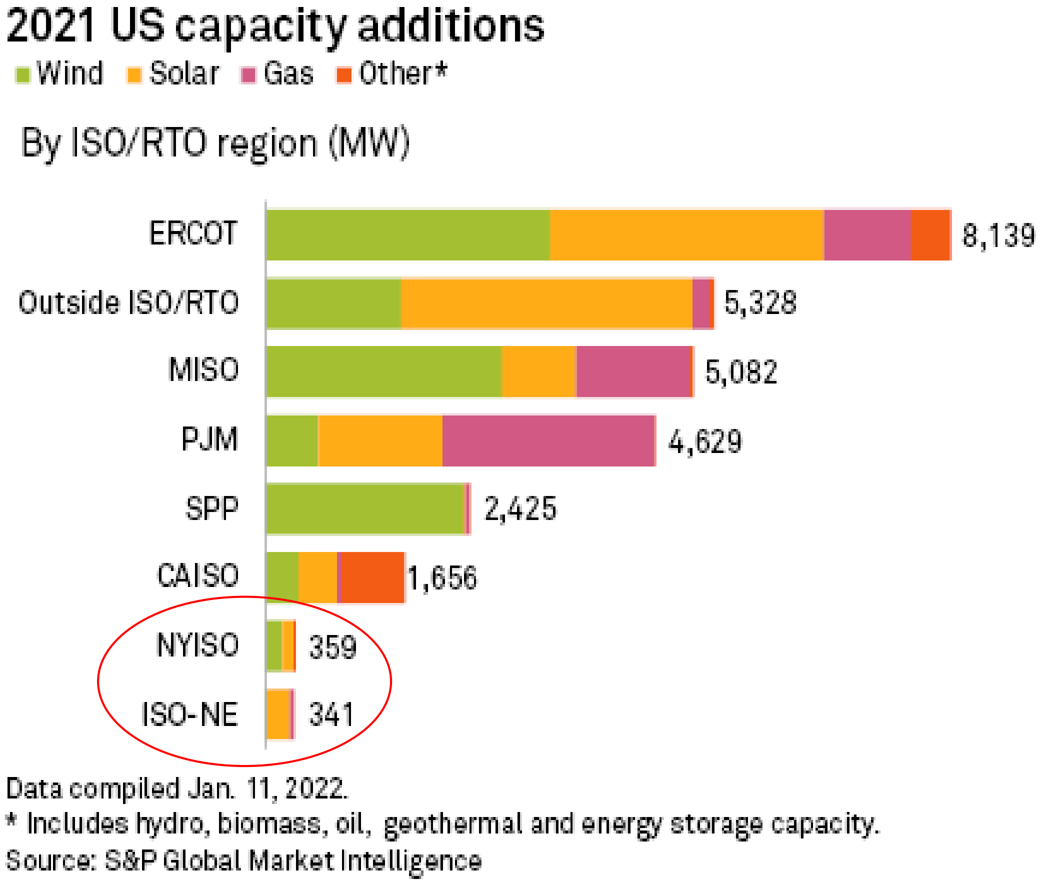
Source: Achieving New England's Ambitious 2050 Greenhouse Gas Reduction Goals - Brattle

Regional Challenge: Generation Interconnection Processes

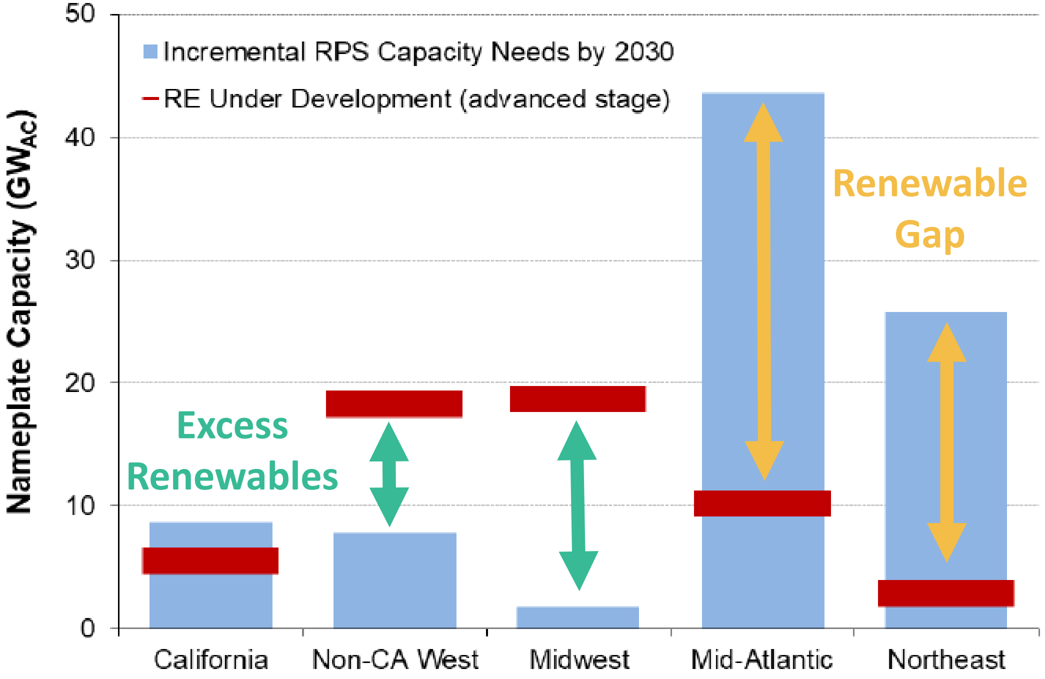
NYISO and ISO-NE have interconnected significantly less renewable generation despite the significant renewable development needs to meet state policies

RTO Size

80 GW
200 GW
150 GW
180 GW
95 GW
52 GW
42 GW
32 GW



Lawrence Berkeley National Lab Estimated Renewables Development Gap



Source: Galen Barbose, “U.S. Renewables Portfolio Standards: 2021 Status Update (Early Release),” Lawrence Berkeley National Lab, Feb 2021. rps.lbl.gov

Current U.S. Transmission Planning is Silo-ed and Inefficient

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

Regional Reliability Projects
Addresses remaining reliability needs

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

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

More proactive multi-value planning is needed to achieve cost-effective planning outcomes

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)

Incremental generation interconnection has become the primary tool (and efficiency barrier) to support public policy goals

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

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

Solution: Proactive Long-Term Transmission Planning*

Available experience already points to proven planning practices that reduce total system costs and risks:

1. **Proactive (rather than incremental) planning for future generation and load** by incorporating realistic projections of the necessary 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.

Experience with Proactive Long-tern Planning Processes

Although still rarely used, significant experience exists with successful proactive, multi-benefit, portfolio-based transmission planning efforts:

	Proactive Planning	Multi-Benefit	Scenario-Based	Portfolio-Based	Interregional Transmission
CAISO TEAM (2004)[146]	✓	✓	✓		
ATC Paddock-Rockdale (2007)[147]	✓	✓	✓		
ERCOT CREZ (2008)[148]	✓			✓	
MISO RGOS (2010)[149]	✓	✓		✓	
EIPC (2010-2013)[150]	✓		✓	✓	✓
PJM renewable integration study (2014)[151]	✓		✓	✓	
NYISO PPTPP (2019)[152]	✓	✓	✓	✓	
ERCOT LTSA (2020)[153]	✓		✓		
SPP ITP Process (2020)[154]		✓		✓	
PJM Offshore Tx Study (2021)[155]	✓		✓	✓	
MISO RIIA (2021)[156]	✓	✓	✓	✓	
Australian Examples:					
- AEMO ISP (2020)[157]	✓	✓	✓	✓	✓
- Transgrid Energy Vision (2021)[158]	✓	✓	✓	✓	✓

Source: Transmission Planning for the 21st Century: Proven Practices that Increase Value and Reduce Costs (brattle.com)

See also: Pfeifenberger, Proactive, Scenario-Based, Multi-Value Transmission Planning, PJM Long-Term Transmission Planning Workshop, June 7, 2022.

Examples of Proactive Multi-value Transmission Planning

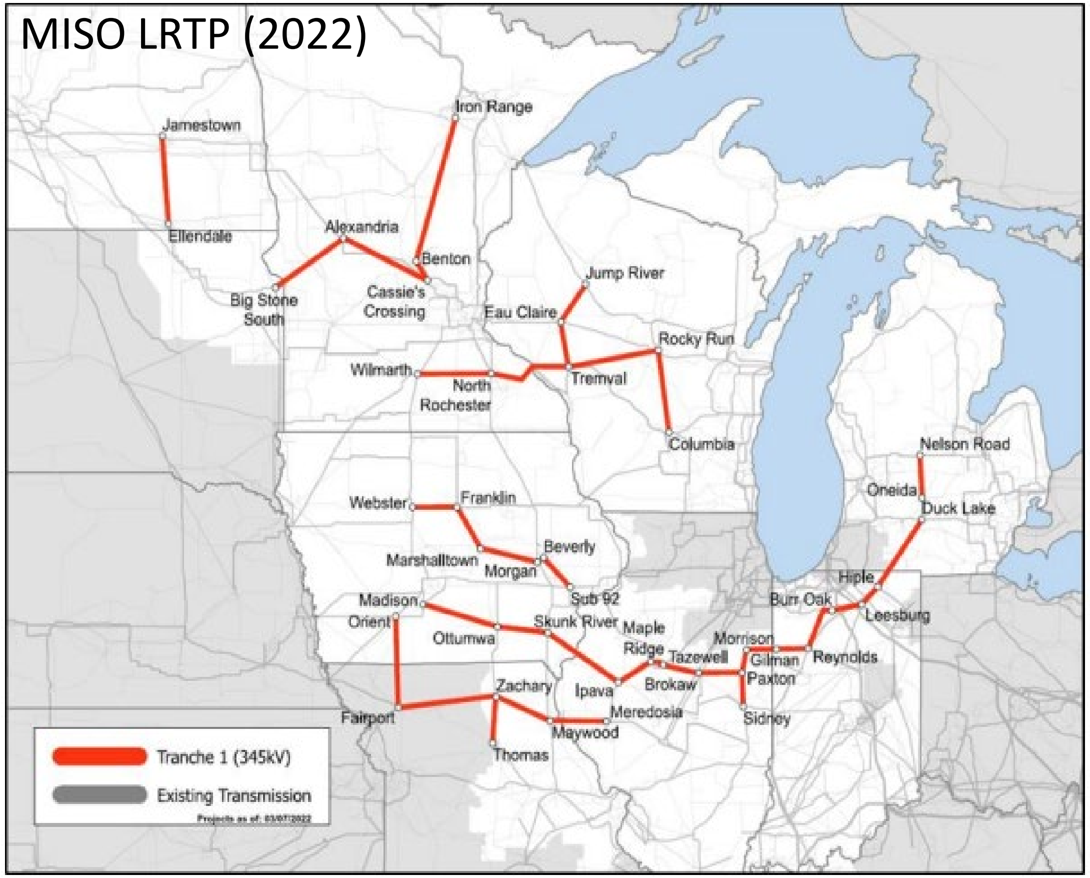
Proactive multi-value transmission planning will be necessary to create a cost-effective grid and to reduce the cost and time required to interconnect renewables at scale

MISO 2022 LRTP results

- Tranche 1: $10 billion portfolio of proposed new 345 kV transmission projects for its Midwestern footprint
- Supports interconnection of 53,000 MW of renewable resources
- Reduces other costs by $37-68 billion

PJM Transmission Study

- Proactively evaluated all existing state public policy needs
- Identified only $3.2 billion in upgrades to integrate 75,000 MW of renewables ($40/kW)
- Would be significantly more cost effective than continued reliance on incremental upgrades through PJM's interconnection process



Proactive Planning Also Streamlines Generation Interconnection

Improving generation interconnection requires addressing all five elements of the GI process (with most current reform discussions focused mostly on Nos. 1 and 5):

1. **GI Process and Queue Management:** individual vs. cluster studies, type of studies and contractual agreements, readiness criteria, financial deposits, study and restudy sequences, etc.
2. **GI Scope and "Handoff" to Regional Transmission Planning:** are major ("deep") network upgrades triggered by incremental generation interconnection requests or handled through regional transmission planning?
3. **GI Study Approach and Criteria:** study assumptions, modeling approaches, and specific criteria differ significantly across regions (e.g., ERIS vs. NRIS study differences, injection levels studied, are market-based redispatch opportunities considered?)
4. **Selecting Solutions to Address the Identified Criteria Violations:** most regions select only traditional transmission upgrades to address criteria violations; grid-enhancing technologies, such as power-flow-control devices or dynamic line ratings, are not typically considered or accepted
5. **Cost Allocation:** most regions require the interconnecting generator (or group of generators) to pay for all upgrades identified, even though (a) there may be significant regional benefits to loads and other market participants and (b) more cost effective (multi-value) regional solutions may exist

Further Improvements to the Generation Interconnection Process

Reducing the scope of upgrades triggered by generation interconnection processes likely would both accelerate and lower the cost of renewable interconnection:

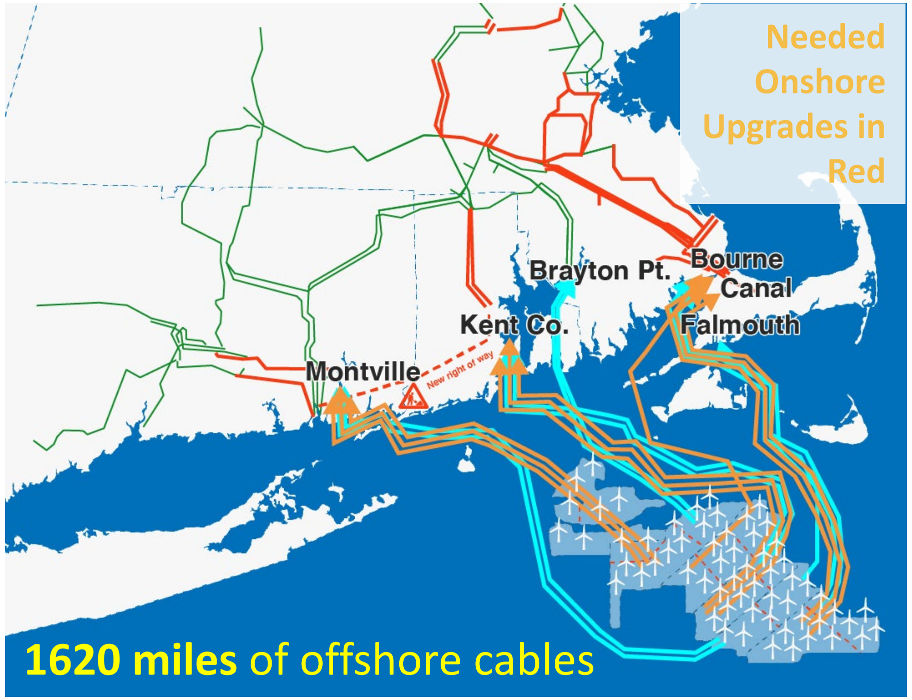
- Attractive: UK "Connect and Manage" (replaced prior "Invest and Connect")
  - Similar to ERCOT; reduced lead times by 5 years; network constraints addressed later (e.g., with congestion management) https://www.gov.uk/guidance/electricity-network-delivery-and-access#connect-and-manage
- ERCOT's generation interconnection process is perhaps most effective in the U.S.
  - Efficient handoff of study roles by ERCOT and Transmission Owners limits restudy needs
  - Projects can be developed and interconnected within 2-3 years; in other regions, the interconnection study process itself may take longer than that
  - Upgrades focused only on local interconnection needs and are recovered through postage stamp
  - Network constraints managed through market dispatch – which imposes high congestion and curtailment risks on interconnecting generators … in part due to ERCOT's insufficiently proactive multi-value grid planning
  - See working-paper.pdf (enelgreenpower.com) [Note: Brattle was not involved]

Generation interconnection based on "connect and manage" when combined with proactive transmission planning offers more timely and cost-effective solutions

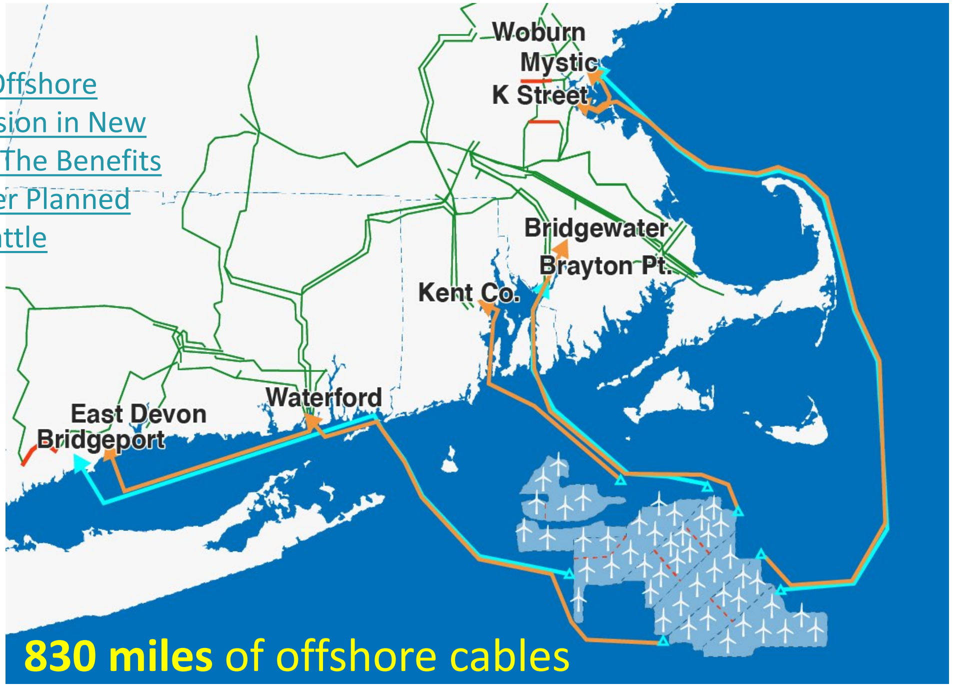
See also: ESIG, Special Topic Webinar: Interconnection Study Criteria, May 31, 2022.

The Benefits of Proactive Planning: OSW for New England

Plausible Gen Tie Approach (for 8400 MW)



Planned Grid Approach (for 8400 MW)



Source: [Offshore Transmission in New England: The Benefits of a Better Planned Grid - Brattle]

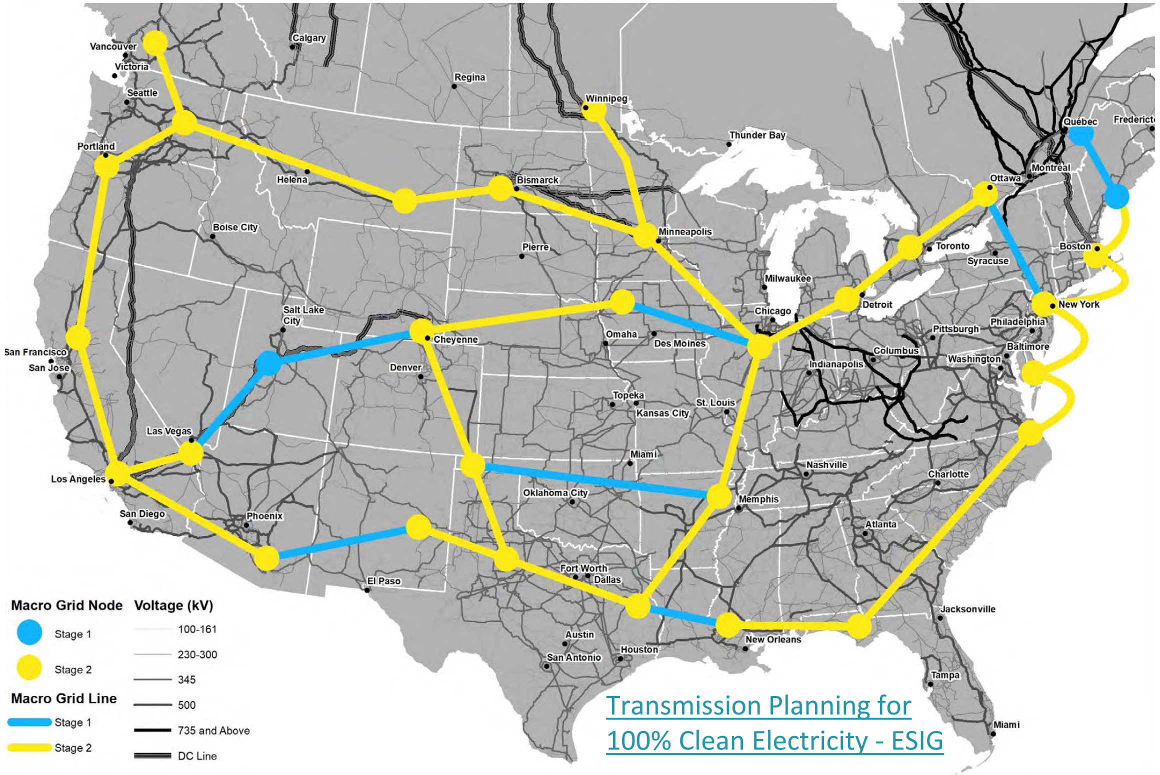
Avoids high-costs of onshore upgrades reduces total costs and risks; reduces the number of offshore platforms, cabling, seabed disturbance, and beach crossings.

A Transmission Blueprint for New England: Pro-active public-policy planning and cost-allocation proposal for: (a) 4x1,200 MW of offshore wind for (MA, CT, RI, commercials); (b) 1,200 MW of northern Maine renewables; (c) grid upgrades in VT and NH.

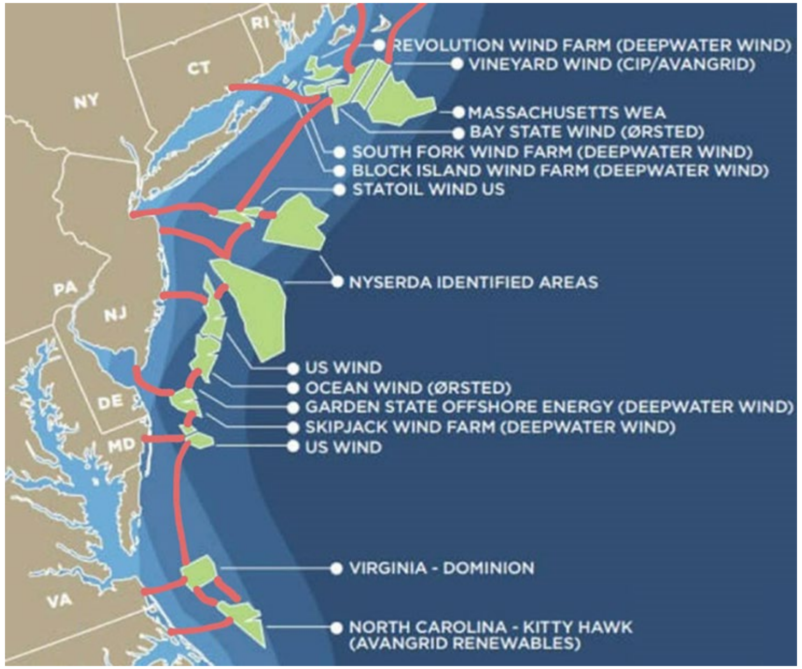
Long-term Challenge: Can Regions be Integrated Into a More Geographically-Diverse Grid to Lower Total Costs?

As state and regional shares of renewable generation (including offshore wind) increase, a robust interregional grid will become more important to ensuring 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 **more 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 beyond size of large weather systems



[Transmission Planning for 100% Clean Electricity - ESIG]



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

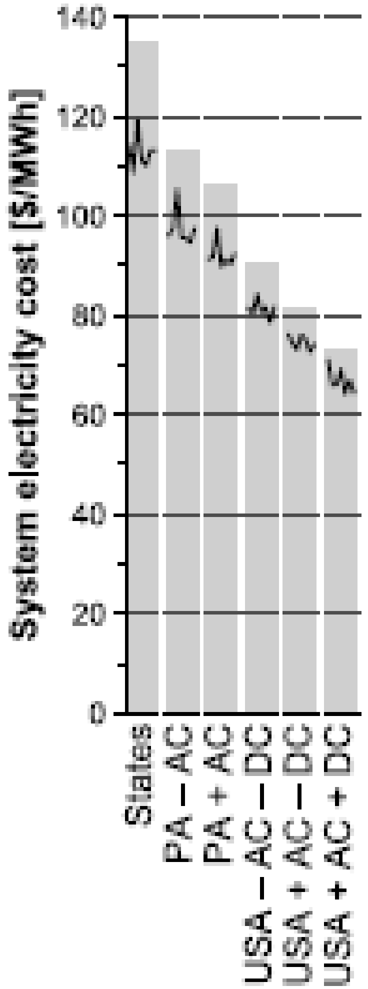
Many Studies Show Large Benefit of Interregional Transmission

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

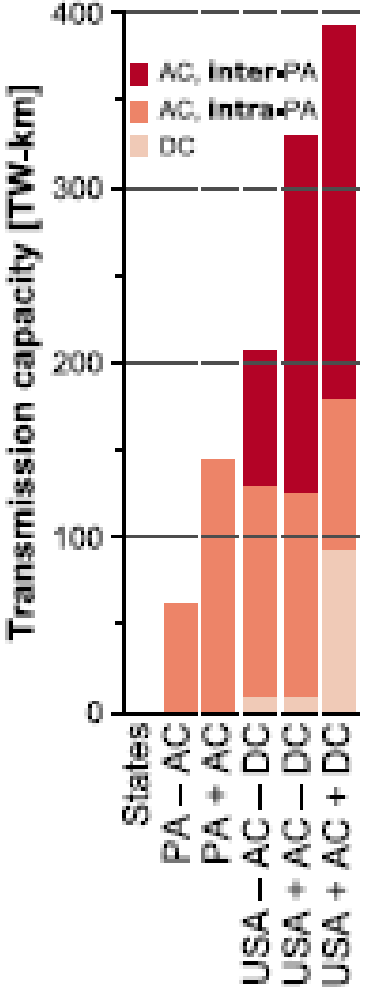
Source: A Roadmap to Improved Interregional Transmission Planning, November 30, 2021.

Example: MIT Value of Interregional Coordination (2021)

TOTAL COST

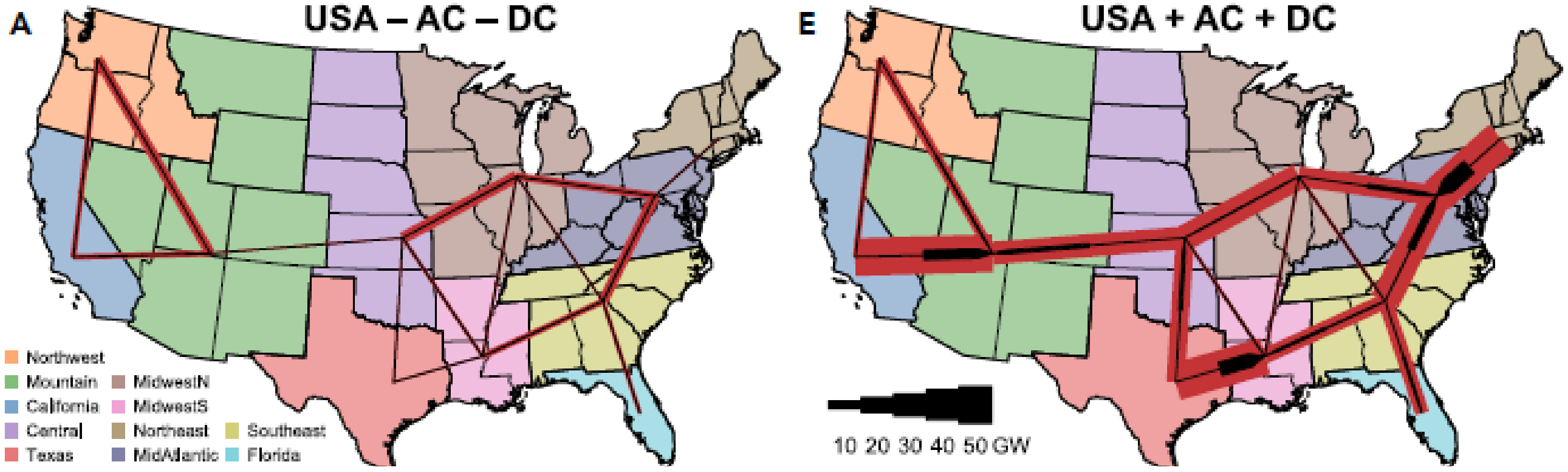


TRANSMISSION



Key Result: A more robust national grid would 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



Challenges Faced in Developing Interregional Transmission

Large inter-regional transmission projects are extremely difficult to plan, as values are poorly understood and no mechanism for cost recovery exists

- Inter-regional planning is a voluntary and ad-hoc process
- Reliability needs (the main driver of regional planning) rarely apply to interregional projects and economic benefits of interregional transmission are not well understood, rarely quantified, or inconsistently analyzed by regions
- Cost recovery (cost allocation) highly contentious and not specified for interregional projects

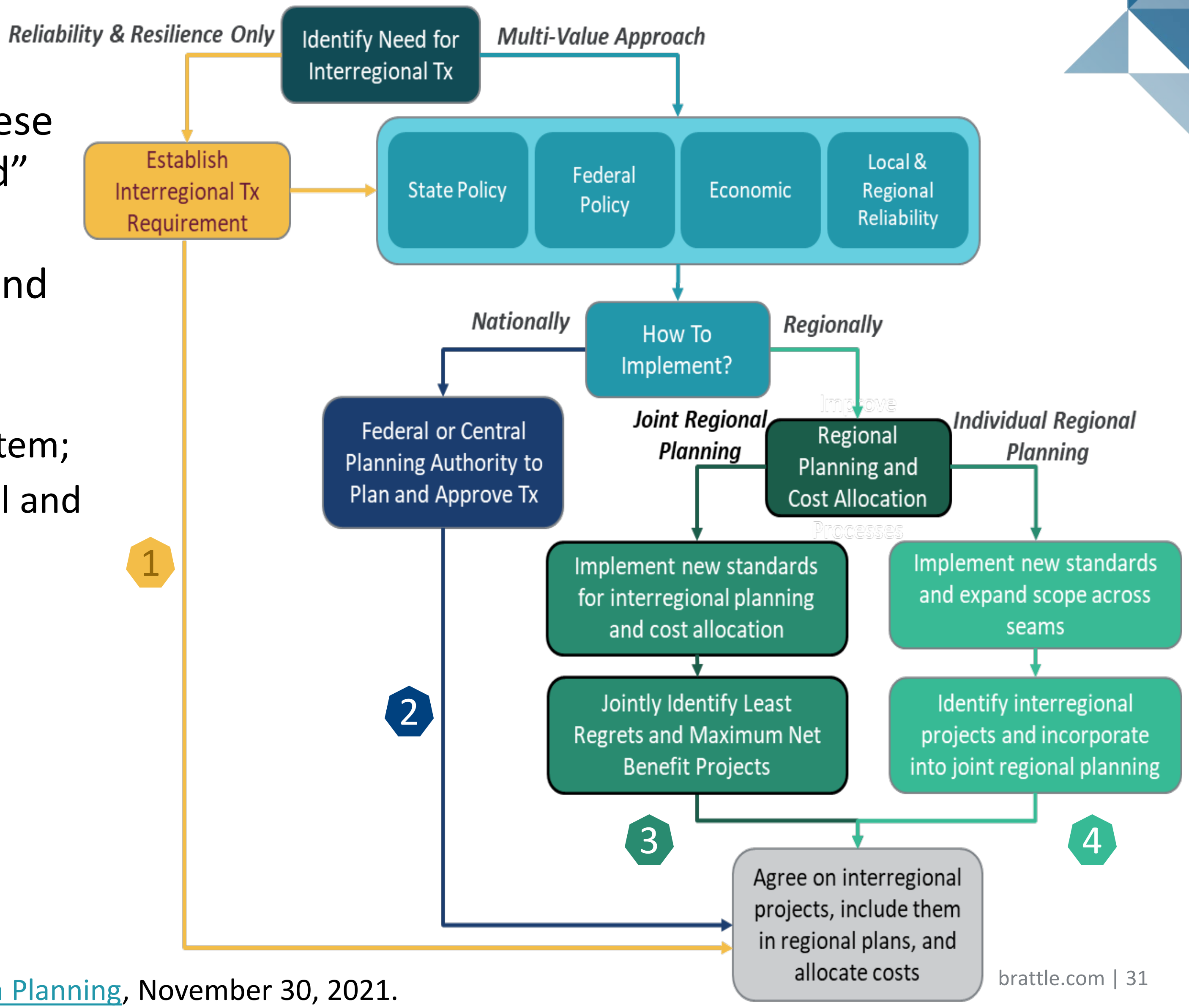
Unlike transmission planning for vertically-integrated utilities and some regional planning efforts, inter-regional transmission planning is not coordinated with long-term generation planning

- Long-term transmission and generation planning tend to be disconnected, both in process and in analytical approach
- Many inter-regional renewable integration studies focus on renewable generation investments, but tend to use generic public-policy and transmission assumptions with limited credibility, not reflecting regional and state-level differences

Regional planning will tend to pre-empt more valuable and cost effective interregional solutions

Four Pathways to Improved Interregional Transmission Planning

- While national studies show there are benefits of interregional transmission, these studies do not create an actionable "need" for approving projects
- Multiple paths to establish the need for and planning of interregional transmission projects based on:
  - the value they provide to the electricity system;
  - planning process implementation by federal and regional planning authorities
- **Four paths for identifying interregional needs can be pursued simultaneously:**
  1. **Interregional Tx reliability requirements?**
  2. **A national planning effort?**
  3. **Improved joint RTO planning**
  4. **Expanded planning by individual RTOs**



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

About the Speaker

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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 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 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
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Link: Well-Planned Transmission

PREPARED BY
Judy W. Chang
Johannes P. Pfeifenberger

May 2016

THE Brattle GROUP

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

PREPARED BY

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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

Summarizes proven approaches to quantifying various benefits

Additional Reading on Transmission

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Our 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

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- Environmental Litigation & Regulation
- Intellectual Property
- International Arbitration
- International Trade
- Labor & Employment
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- Product Liability
- Securities & Finance
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