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# 2050 Transmission Study

## *Solution Development Update*

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# Purpose & Outline of Today's Presentation

- Today's presentation is a progress update on transmission solution development for the 2050 Transmission Study
- All results presented today are preliminary and subject to change as the study progresses
- Today's presentation will cover the following topics:
  - 2050 Transmission Study Overview
  - Solution Development Progress
  - Approach for Detailed Cost Estimates
  - Defining "High-Likelihood" Concerns
  - Feedback and Next Steps

# 2050 TRANSMISSION STUDY OVERVIEW

# 2050 Transmission Study Overview

- In accordance with a recommendation from NESCOE's October 2020 "*New England States' Vision for a Clean, Affordable, and Reliable 21st Century Regional Electric Grid*," ISO-NE is conducting the 2050 Transmission Study in order to determine:
  - Transmission needs in order to serve load while satisfying NERC, NPCC, and ISO-NE reliability criteria in 2035, 2040, and 2050
  - Transmission upgrade "roadmaps" to satisfy those needs considering both constructability and cost

- ISO-NE has coordinated with NESCOE throughout this study
  - In November 2021, ISO-NE introduced the 2050 Transmission Planning Study Scope of Work, preliminary assumptions, and methodology
  - ISO-NE presented results showing transmission reliability concerns in peak load snapshots in March 2022, April 2022, and July 2022
  - ISO-NE presented an initial round of proposed solutions in December 2022
    - Several potential solutions were proposed, including solutions in SWCT and Boston

- Today's presentation is an update on transmission solution development
  - The solutions presented today are in addition to those presented in December 2022

- This study is meant to evaluate potential transmission scenarios and sample transmission upgrades, and is not a recommendation to develop specific transmission or generation projects

# 2050 Study Solution Development Process

*More details were shown at the April 28, 2022 PAC Meeting*

**2035 & 2040 Solution Subset**

- Subsets of primary solution set to fully address needs in 2035 and 2040

**Primary Solution Set**

- 2050 Winter Evening Sensitivity (51 GW load)
- 2050 Summer Daytime Peak Sensitivity
- 2050 Summer Evening A & B

**High Winter Peak Solution Set**

- Additional solutions to fully address original 2050 Winter Peak (57 GW load)

# 2050 Study Solution Development: Current Status

- The primary set of solutions is nearing completion
- Development of a subset of the primary solution set consisting of solutions needed by 2035 or 2040 is in progress
- Solution development for the High Winter Peak solution set (2050 Winter with 57 GW of load) is also in progress

# SOLUTION DEVELOPMENT PROGRESS

# Solution Development Overview

- The potential solutions that will be discussed today largely fall into the following categories:
  - Lines that can be rebuilt with larger conductors* to avoid overloads
  - New lines needed to fix an individual overload that cannot be addressed by a rebuild
  - New lines that fix a large number of overloads in a sub-region
    - A comparison of costs will be made in the final results to determine whether it is more cost-efficient to build new lines or to rebuild existing lines
- The next several slides will cover a variety of potential solutions that fall into some of these categories

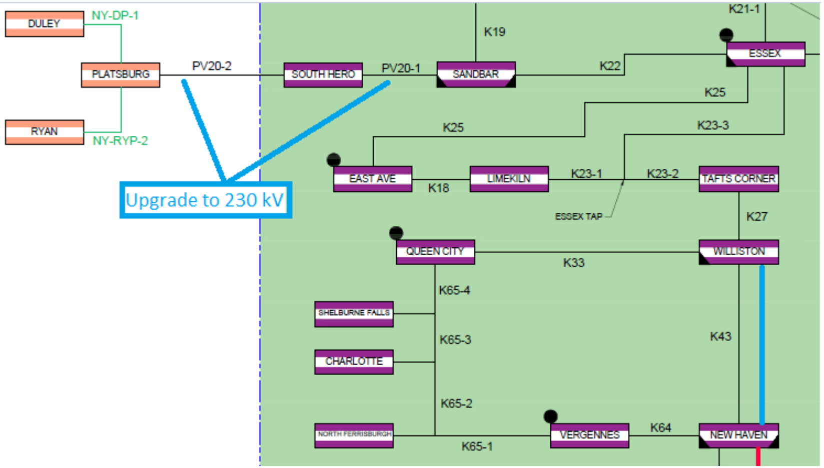
* More information on rebuilds can be seen in the December 2022 presentation

# Solutions in Vermont

- Overloads in Vermont are primarily caused by large power transfers towards the Burlington area in northwestern Vermont
- Overloads were observed in multiple seasonal peak snapshots
- Many overloads can be resolved by rebuilding overhead lines; however, several underground/underwater sections would be very costly or difficult to rebuild
  - Overloads on the PV-20 115 kV cable underneath Lake Champlain, connecting to Plattsburgh, NY, cannot be mitigated with the equipment that controls flows on this line today
- Broader Vermont solution alternatives are being investigated that can avoid the need for many rebuilds while also solving the underground overloads

# Solutions in Vermont, cont.

- One option is to upgrade the PV-20 line from New York from 115 kV to 230 kV and build a new 115 kV line parallel to line K43 (shown in blue)
  - Plattsburgh, NY is already connected to an existing 230 kV system in northern NY
  - Underground and underwater segments of PV-20 are already built for 230 kV; only overhead segments would need to be upgraded

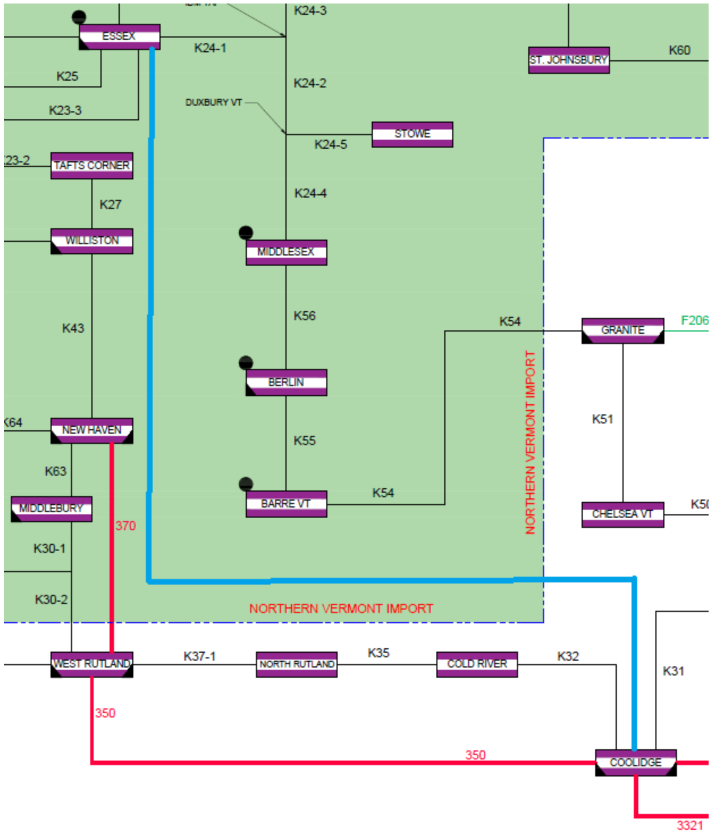



- Advantages:
  - Likely the cheapest solution, significantly fewer miles of new lines
  - Avoids many overhead rebuilds and most underground rebuilds
  - Could lead to increased NY-NE transfer capability and decreased curtailment of resources in northern NY

- Disadvantages:
  - Construction would be required in New York for the PV-20 upgrade to 230 kV

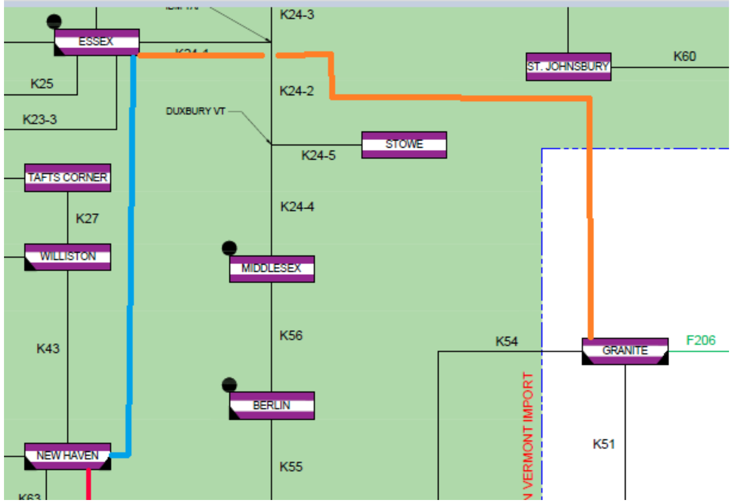
# Solutions in Vermont, cont.

- Another option being considered is to build a new 345 kV line (shown in blue) from Coolidge to Essex
- Advantages:
  - Avoids many overhead rebuilds and the most difficult underground rebuilds
  - New construction is entirely within New England
- Disadvantages:
  - Significantly more new construction is required when compared to the other solutions, although this new transmission could follow existing rights-of-way
  - Longer mileage of new transmission may lead to a higher overall cost



# Solutions in Vermont, cont.

- A third option is to build a new 345 kV line from New Haven to Essex (shown in blue) and build a new 230 kV line from Granite to Essex (shown in orange)
- Advantages:
  - Avoids many overhead rebuilds and most underground rebuilds
  - New construction is entirely within New England
  - Requires less new transmission construction than the Coolidge to Essex solution
- Disadvantages:
  - Requires the addition of two new transformers at Essex, rather than one
  - Limits the use of the Granite 115 kV PARs to control flow on the existing 230 kV lines in Vermont and New Hampshire

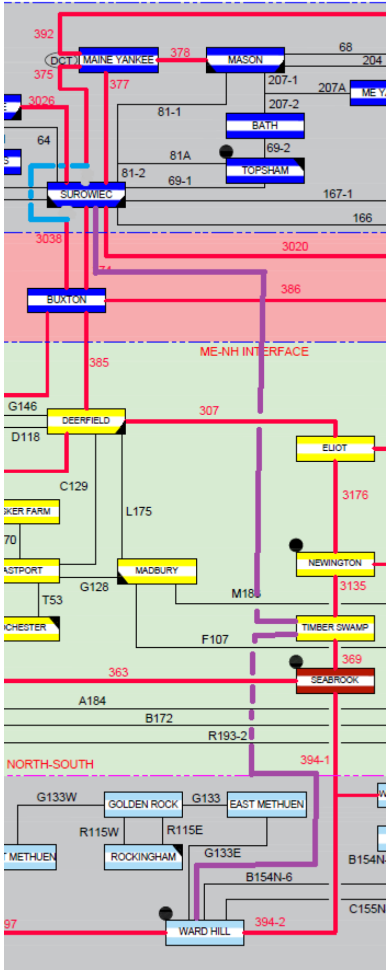


# North – South Solutions

- Many of the major lines running from north to south in Maine, New Hampshire, and Massachusetts overload due to excess generation in the north and significant amounts of load in southern New England
- Overloads were observed in multiple seasonal peak snapshots
- In the Primary Solution Set and in the 2035 & 2040 Solution Subset, all of these overloads can be resolved with rebuilds, although there may be common solutions that can resolve the need for rebuilds in a cheaper manner
- Moving to the High Winter Peak Solution Set (57 GW winter), many of these overloads become too severe to be covered by rebuilding lines

# North – South Solutions, cont.

- One solution being considered is to re-route lines 375 and 3038 to avoid Surowiec, instead going straight from Maine Yankee – Buxton (show in blue), and to then build a new 345 kV line from Surowiec – Timber Swamp – Ward Hill (shown in purple)
- This resolves many of the rebuilds needed in the Primary Solution Set and in the 2035 & 2040 Solution Subset
  - To complete the High Winter Peak Solution Set, a second line 345 kV line from Timber Swamp – Ward Hill may be needed
- Advantages:
  - Significantly reduces the need for rebuilds on existing transmission lines, possibly leading to better cost efficiency
  - Additional 345 kV line across major interfaces will likely improve voltage and stability performance
- Disadvantages:
  - Right-of-way space for some segments of this project will be very tight
  - Increased reliance on a single 345 kV right-of-way for moving power from north to south



# North – South Solutions, cont.

- Another solution being considered is an HVDC line directly from Surowiec 345 kV to Mystic 345 kV
  - This solution also includes the re-route of lines 375 and 3038 to form a new Maine Yankee – Buxton 345 kV AC line that was mentioned on the previous slide
- This solution resolves many of the North – South transfer issues, along with many of the Boston Import problems, while avoiding increased reliance on a single 345 kV right-of-way
- This solution, combined with several 345 kV line rebuilds, is sufficient for solving North – South overloads as well as most Boston overloads in the Primary Solution Set as well as the 2035 & 2040 Solution Subset
- Additional solutions, potentially multiple HVDC lines (point-to-point or in an offshore network) will be needed to meet the High Winter Peak (57 GW) Solution Set

# North – South Solutions, cont.

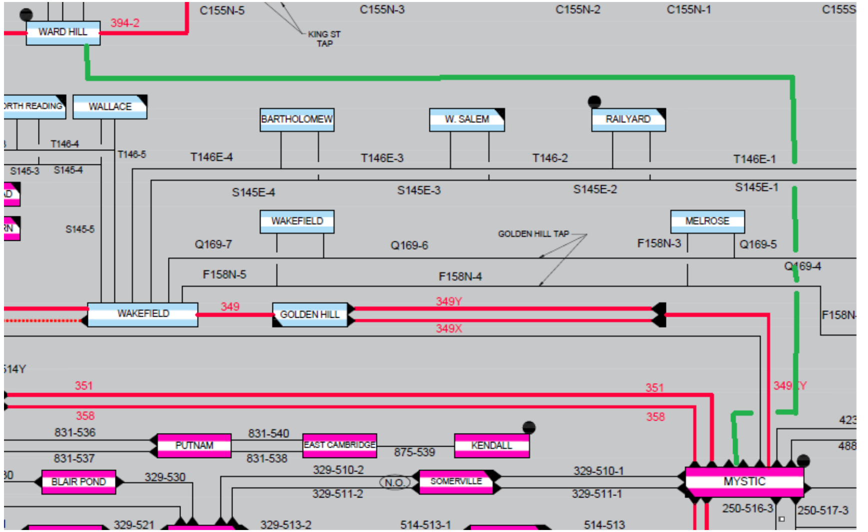
- Other HVDC lines between points in Maine (such as Orrington or Surowiec) and western New England (such as Ludlow or Manchester) are also being tested to alleviate North – South and East – West constraints in the High Winter Peak Solution Set
- This solution helps to alleviate significant numbers of North – South overloads
- However, it does not address Boston Import issues, and the length of the line may make it expensive and difficult to site

# Boston Import Solutions

- Many overloads in the Boston area are related to high flows into the Boston area under both summer and winter peak conditions
- There are a significant number of underground overloads in Boston that will likely be expensive to fix directly
- A variety of underground violations in Boston are observed to occur in at least some of the snapshots for each season and each year studied in the 2050 Transmission Study
  - Boston requires more import capability than what it currently has in these snapshots
  - Differences in violations across snapshots are due to a combination of load and wind growing at different rates between 2035, 2040, and 2050 and differences in wind output in summer vs. winter
    - For example, more overloads are seen in Boston for the 2040 Winter Peak snapshot than for the 2050 Winter Peak 51 GW snapshot because although load is higher in 2050 than in 2040, the growth in wind injections into Boston outpaces the load difference between 2040 and 2050

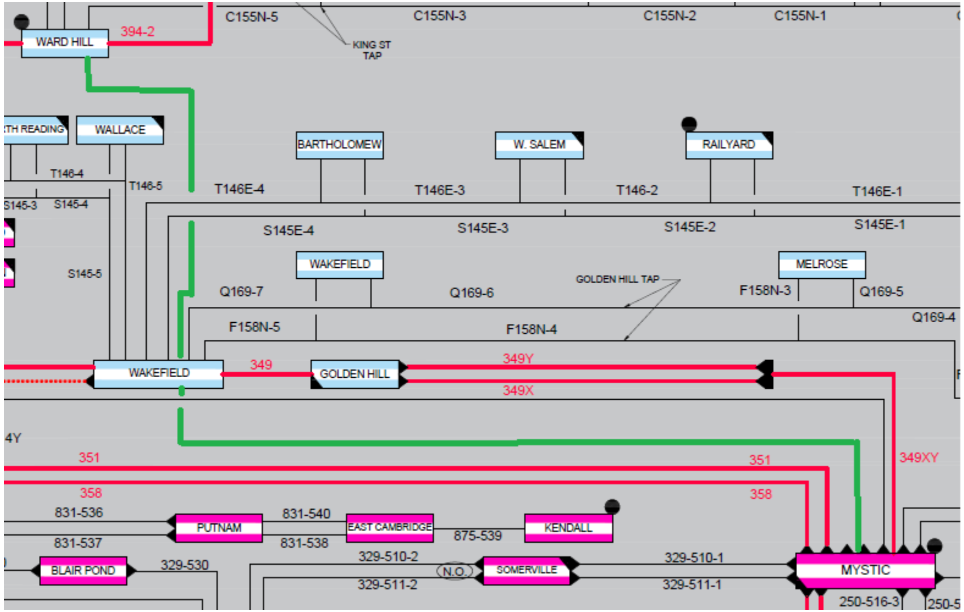
# Boston Import Solutions, cont.

- One option to reduce Boston import violations is to build an HVDC line from Ward Hill – Mystic (shown in green)
  - This is being tested separately from the Surowiec – Mystic option mentioned in the North – South solutions, and these two can be considered mutually exclusive
- Advantages:
  - This solution significantly reduces the number of overloaded underground elements in Boston without needing to upgrade them directly
  - Avoids possible short-circuit impacts of new 345 kV AC construction
- Disadvantages:
  - This option may be quite expensive (still pending detailed cost estimate)
  - Physical space for HVDC converter stations near Ward Hill and Mystic may be a challenge



# Boston Import Solutions, cont.

- An alternative to an HVDC line would be to install a 345 kV AC line from Ward Hill – Wakefield Junction – Mystic (shown in green)
  - This line would be partially overhead and partially underground, depending on right-of-way availability
- Advantages:
  - This solution may be cheaper than the HVDC option (detailed cost estimates are being obtained for both options for comparison)
- Disadvantages:
  - This option is slightly less effective at solving underground overloads in Boston, although it still performs well overall



# Boston Import Solutions, cont.

- Lines serving Boston from the south are also overloaded, with Stoughton – K Street overloading in several snapshots
- Two solutions are being considered to resolve this:
  - Add a third Stoughton – K Street cable
  - Add series reactors on the two existing Stoughton – K Street cables
- This will likely be a trade-off between cost and effectiveness, with a third cable likely being more effective than the series reactors but also likely more expensive

# HVDC Line Configurations

- Multiple different HVDC lines are being examined in the 2050 Transmission Study
  - Some are being studied directly in a point-to-point configuration, such as Surowiec – Mystic
  - Others are implied through wind injections modeled as large generators at transmission-level buses
- The 2050 Transmission Study looks at these HVDC lines individually; however, it is also possible that these lines could be connected together to form an offshore grid

# APPROACH FOR DETAILED COST ESTIMATES

# Detailed Cost Estimates

- ISO New England has hired Electrical Consultants Inc. (ECI) to develop detailed cost estimates for some of the more complex solutions that have been developed
- These estimates focus primarily on complex solutions such as HVDC, underground cables, new lines through areas with limited physical space, etc.
- Detailed cost estimates will help to inform the region on both the costs and physical impacts of the projects examined

# Considerations for Detailed Costs

- The ISO is advising the consultant to take the following into account:
  - Avoiding creating double-circuit towers where possible, especially on the 345 kV network
  - Placing transmission lines underground as necessary to avoid using eminent domain or relocating residents
  - Allowing new overhead lines to be built along existing corridors (highways, railroads, etc.) to ease siting constraints

# DEFINING "HIGH-LIKELIHOOD" CONCERNS

# Motivation for "High-Likelihood" Concerns

- NESCOE and other stakeholders have expressed their interest in identifying system concerns that would be most likely to appear, and most helpful to resolve
  - These concerns are those that would appear under a wide variety of conditions, including conditions that do not exactly match those examined in the 2050 Transmission Study
- The ISO would like to lay out a proposal for determining which concerns in the 2050 Transmission Study are "high-likelihood" concerns
- Not all concerns identified in this study can be or will be "high-likelihood" concerns
  - Some concerns appear only for a very specific set of circumstances

# What is a “High-Likelihood” Concern?

- The ISO proposes that a “high-likelihood” concern is one that appears under a wide range of conditions
- This means that the concern is observed in more than one snapshot
  - Variations in actual system evolution between 2023 and 2050 will likely result in a reality that does not exactly match the assumptions in the 2050 Transmission Study
  - For example, if a concern appears in the 57 GW Winter Peak snapshot but is not observed for any other scenario at a lower load, then this is likely not a “high-likelihood” concern
- A “high-likelihood” concern should also be robust for small to moderate differences in load and generation locations
  - Generator locations and load distributions in the 2050 Transmission Study are assumed, and may not match the eventual evolution of the power system

# Optimizing Generator Locations To Identify "High-Likelihood" Concerns

- The 2050 Transmission Study has already optimized generator locations within import-constrained areas to the degree possible, while staying consistent with both the study's objective and the inputs from the Energy Pathways study
  - This optimization includes:
    - Offshore wind interconnections in Boston and Southwest Connecticut
    - Battery storage interconnections generally being placed in load-dense areas
- After optimizing generator locations, concerns observed in these areas may be considered "high-likelihood" concerns
  - This means that concerns observed in the 2050 Transmission Study in these areas will be necessary even if generators are interconnected at the optimal locations

# "High-Likelihood" Concerns Proposal

- For each concern identified in the 2050 study, the ISO proposes to use the following criteria to determine whether the concern is "high-likelihood:"
  - The concern must be observed for at least two of the studied snapshots, with these two snapshots needing to be either different seasons from each other or different years (and hence different load levels) from each other
    - Consideration will also be given to concerns that exist on today's system, or match other ISO-NE study outcomes, such as the Future Grid Reliability Study or Cluster Regional Planning Studies
  - The concern must not be heavily dependent on load growth in a specific area
    - Additional load-serving substations are likely to be built between 2023 and 2050, and these future substations are not included in the 2050 Transmission Study due to a lack of information on their location
    - This means that a concern related to transporting power between sub-regions within New England would be more likely to be considered a "high-likelihood" concern than one that is only related to feeding radial load
  - The concern must not be solely caused by the injection of power from a specific generator at a specific substation
    - The generation locations chosen in the 2050 Transmission Study are not necessarily where actual future generation will be built
    - A concern related to the delivery of a generator's power from a specific interconnection point would not be a "high-likelihood" concern, as this generator may in reality be interconnected to a different station, eliminating this concern

# Example "High-Likelihood" Concern

- In this example, the concerns related to North – South transfers on slides 13 – 16 will be considered
  - Issues observed on the main 345 kV path itself would be "high-likelihood" concerns
    - Power will have to flow along this path to go from the excess generation in the north to the high load in the south, regardless of the specific location of generation and load
  - Overloads on the specific lines that bring power from wind injections in the north to that North-South path would likely not be "high-likelihood"
    - If the generation was instead located one station over, the line connecting that station to the path would likely be the one overloaded instead of the line connecting the previous station to the path

# NEXT STEPS

# Feedback and Next Steps

- Feedback on the 2050 Transmission Study presentation may be submitted to pacmatters@iso-ne.com by May 5, 2023
- Next Steps:
  - Solution development work will continue throughout 2023
  - Detailed cost estimates from ECI are ongoing in parallel with solution development
  - The ISO’s next presentation will likely occur in late summer to early fall of 2023
  - A draft 2050 Transmission Study report is planned to be released by November 2023

# Questions