Transmission Planning for the Clean Energy Transition

Pilot Study Results

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TRANSMISSION PLANNING

Objectives of Today's Presentation

- Share further results from the Transmission Planning for the Clean Energy Transition (TPCET) Pilot Study since the June 16 PAC meeting
- Discuss various strategies to prevent DER from tripping due to transmission system faults
- Discuss future work and schedule for completion of the TPCET Pilot Study

Note: in order to maximize stakeholder involvement, this presentation does not contain Critical Energy Infrastructure Information (CEII). As a result, information about the exact contingencies causing concerns is not being shared at this time.

TPCET PILOT STUDY OVERVIEW

Overview of the TPCET Pilot Study

- New England continues to lead many industry trends
  - Development of Distributed Energy Resources (DER)
  - Integration of renewable resources, including offshore wind
  - Increasing imports via HVDC interconnections
  - Integration of battery energy storage resources
- To quantify trade-offs between cost and ability of the transmission system to accommodate high amounts of renewable resources, ISO-NE is conducting a "pilot" study of certain key system conditions
- The pilot study will aid in developing assumptions for use in future Needs Assessments, and will explore reliability concerns that may arise under these system conditions

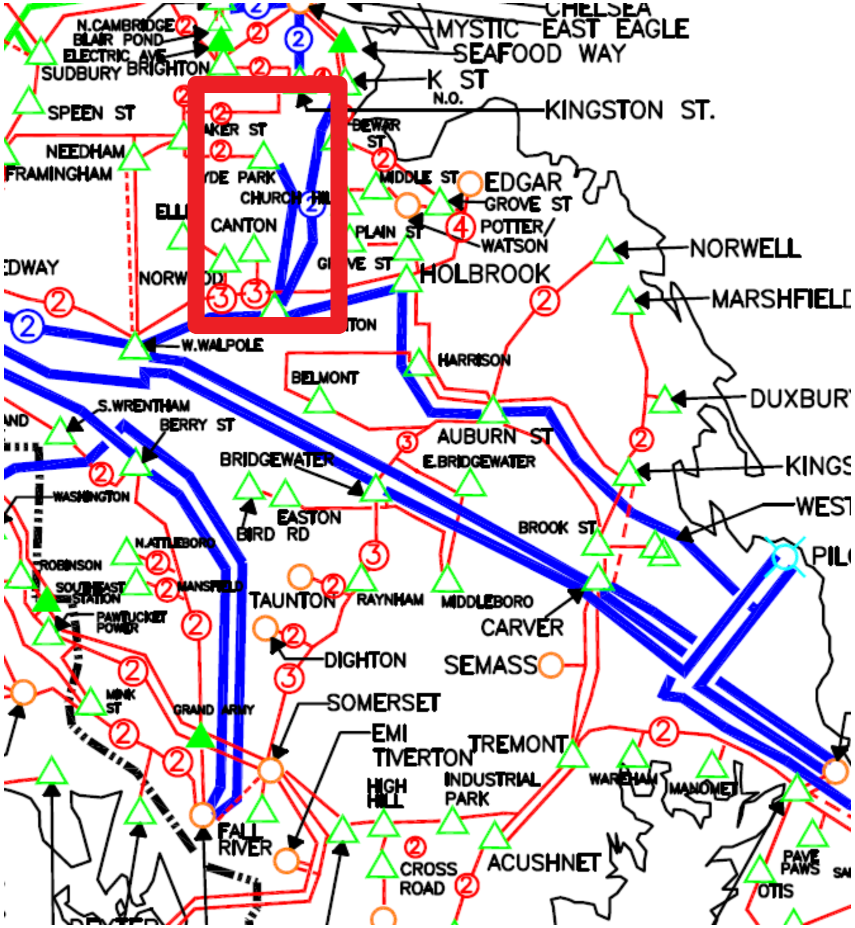
Past PAC Presentations on TPCET Efforts

- Sept. 2020: Introductory Presentation
- Nov. 2020: Updated Assumptions and Pilot Study Proposal
- Dec. 2020: System Conditions and Dispatch Assumptions
- Jan. 2021: Generation Dispatch Details
- June 2021: Preliminary Results

STEADY-STATE RESULTS UPDATE

Stoughton – K St. 345 kV Cable Loading

- Stoughton – K Street cables connect SEMA (high levels of offshore wind) with Boston (a major load center)
- June 2021 PAC presentation identified overloads on these cables in the Summer Weekday Mid-Day Peak Load (High Renewables) study condition



Stoughton – K St. 345 kV Cable Loading

- Generation reductions in SEMA/RI are sufficient to relieve the overloads on the Stoughton – K Street cables
- Due to renewable resource additions in SEMA/RI, including over 3,100 MW of offshore wind and 2,300 MW of PV, reductions in fossil-fueled generation in the base case had already been focused in SEMA/RI
- In addition to these initial generation reductions, another 30 MW of fossil-fueled generation was reduced in SEMA/RI to alleviate the Stoughton – K Street cable overloads
- In total, 5,150 MW of fossil-fueled generation was kept offline in SEMA/RI to avoid Stoughton – K Street cable overloads

Stoughton – K St. 345 kV Cable Loading

- Thermal overloads are relatively easily managed in real-time operations, and many options exist for generation reduction that would alleviate this constraint
  - Operators can easily identify post-contingency thermal overloads before a contingency occurs, and make system adjustments, such as reducing generation, to avoid overloads
- In a Needs Assessment, a thermal overload is not considered to be a need if it could be resolved by reducing generation
- Currently, enough capacity is available outside of SEMA/RI that this reduction does not cause a reliability concern
  - If significant generator retirements were to occur outside of SEMA/RI, some of this fossil-fueled capacity may be needed to serve load
- ISO-NE will continue the current practice of reducing generation when necessary to avoid overloads

Other Steady-State Results

- The June 2021 PAC presentation identified a number of areas with steady-state high-voltage violations in the Spring Weekend Mid-Day Minimum Load study condition
- Further investigation of these high-voltage violations will occur once representative solutions to stability concerns have been developed
- A comparison between today's Needs Assessment cases and cases with similar generation outages and new load, solar, and wind assumptions will be presented at the August 2021 PAC meeting

STABILITY RESULTS UPDATE

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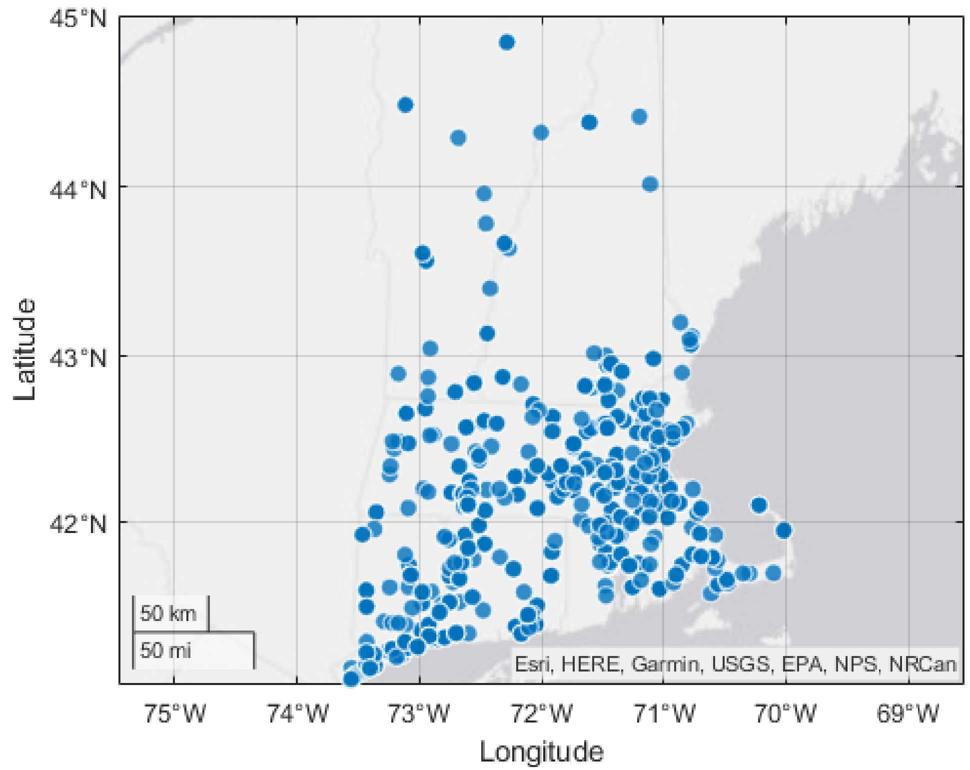
Stability Results Overview

- The June 2021 PAC presentation identified the loss of DER solar installations during and after transmission system faults as the primary stability concern in the TPCET Pilot Study
- Further analysis since June has examined different strategies for reducing the amount of DER tripped
- These results concentrate on "Fault 7" from the June PAC presentation
  - Fault 7 is a single-line-to-ground (SLG) fault with breaker failure on the SEMA/RI 345 kV system
  - This fault resulted in 1,855 MW of DER tripping in the Spring Weekend Mid-Day Minimum Load study condition, and 807 MW of DER tripping in the Summer Weekday Mid-Day Peak Load study condition
  - All other faults tested showed lower amounts of DER tripped

Results: Spring Weekend Mid-Day Minimum Load

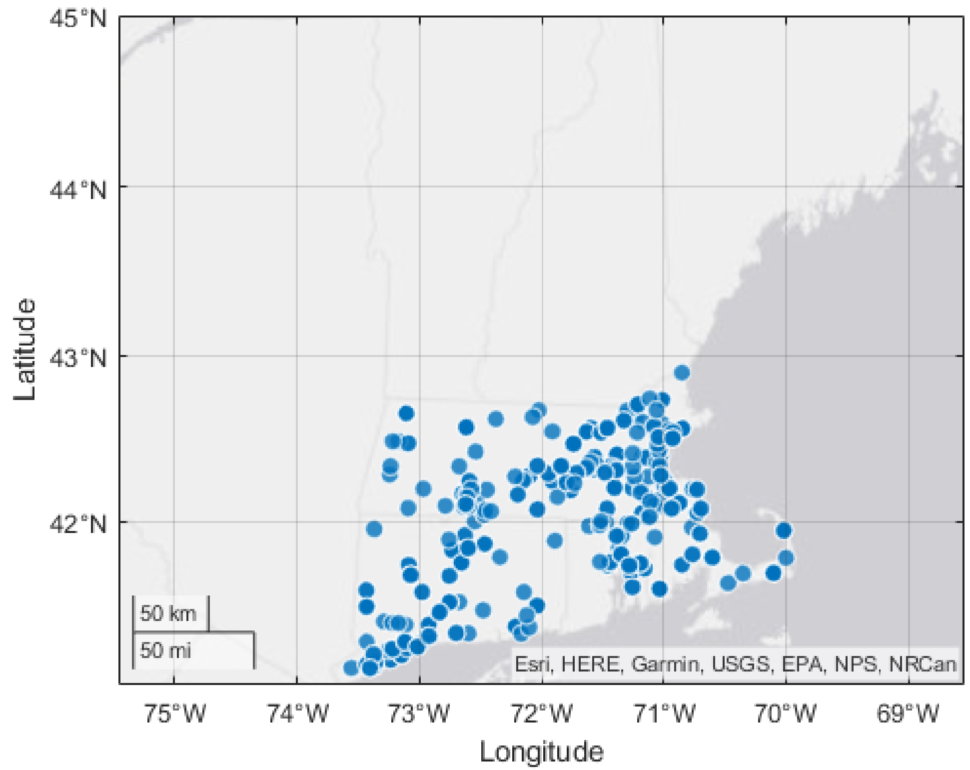
- DER solar output: 90% of nameplate (7,390 MW)
- Amount tripped due to SEMA/RI SLG fault with breaker failure: 1,855 MW



Each blue dot represents a substation where DER solar generation was tripped. DER in the New York system was not explicitly modeled.

Results: Summer Weekday Mid-Day Peak Load (High Renewables)

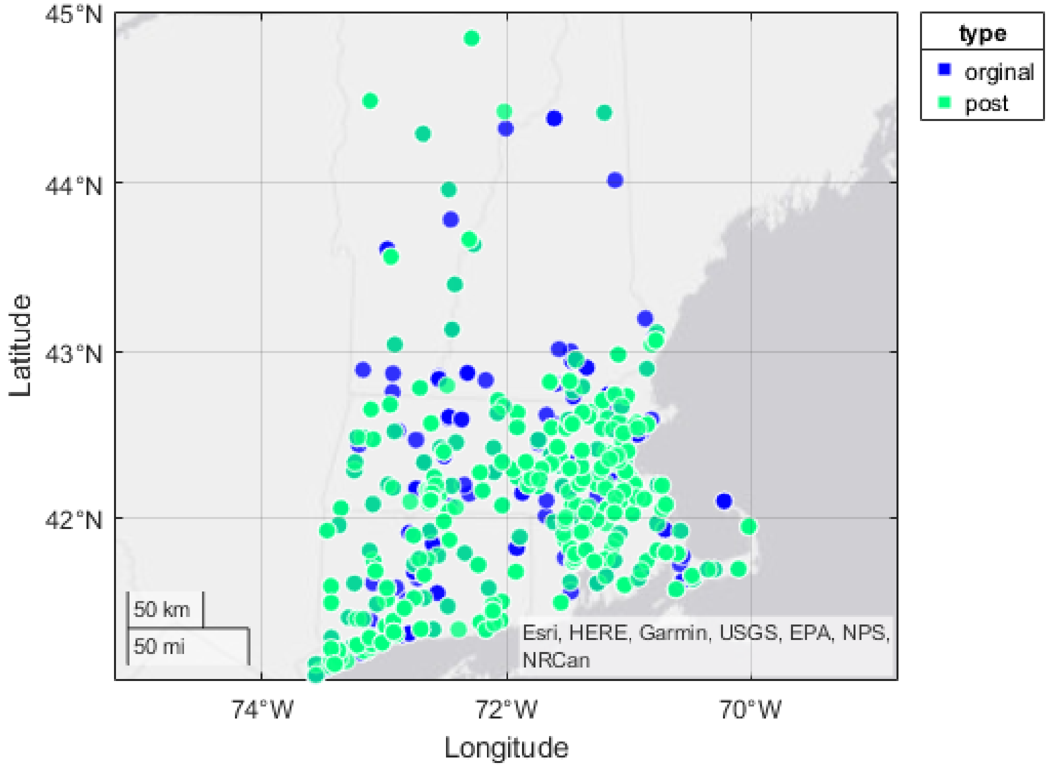
- DER solar output: 65% of nameplate (5,340 MW)
- Amount tripped due to SEMA/RI SLG fault with breaker failure: 807 MW



Each blue dot represents a substation where DER solar generation was tripped. DER in the New York system was not explicitly modeled.

Spring Weekend Mid-Day Minimum Load, Reduced PV Output

- In the spring weekend mid-day minimum load condition, DER solar output was reduced to 50% of nameplate (4,110 MW) and replaced with natural gas generation
- Amount tripped due to SEMA/RI SLG fault with breaker failure: 877 MW
- While some stations' DER now rides through the fault, most of the reduction is due to the lower amount of DER at each station



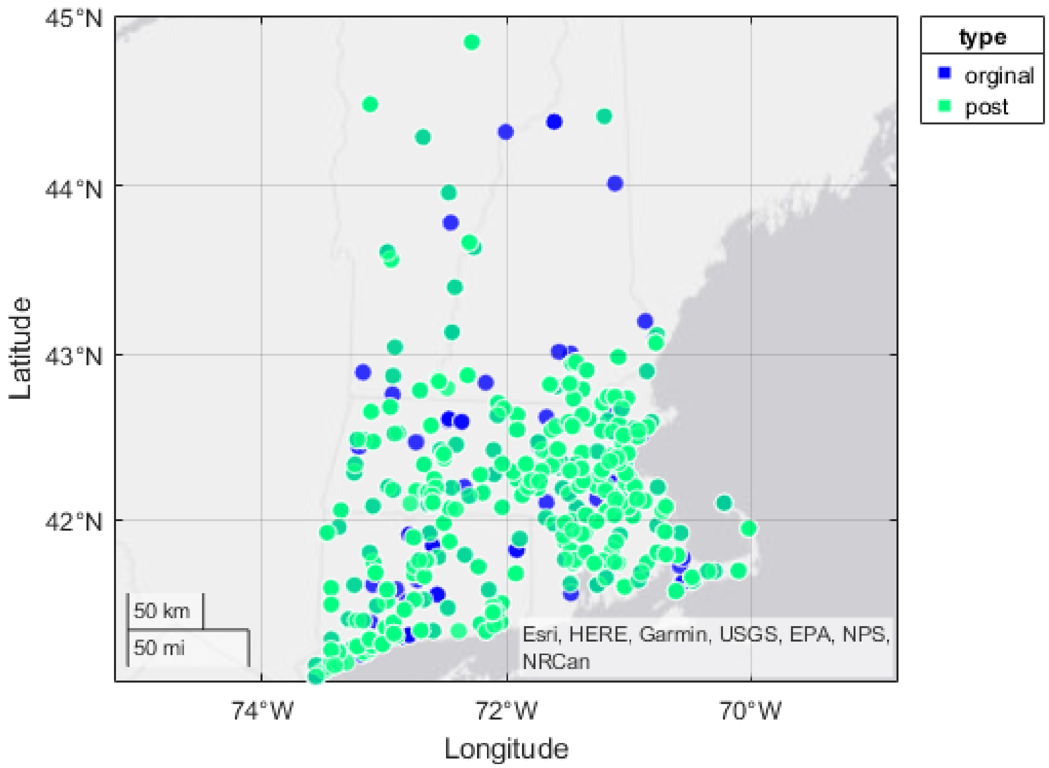
Green dots: DER tripped in this simulation
Blue dots: DER tripped in the original minimum load case (on slide 13), but not in this simulation

Spring Weekend Mid-Day Minimum Load, Reduced PV Output

- The reduced-PV minimum load condition shown on the previous slide is expected to occur somewhat frequently
  - Significant loss of DER for transmission system faults is a concern not only under extreme minimum load conditions
- Two things must occur simultaneously to see a condition similar to the reduced-PV minimum load condition:
  - PV output at or above the level in this condition
  - Synchronous generation (load – solar – wind) at or below the level in this condition
- Based on 2000-2019 data for load, wind, and solar, these two factors could occur with the following frequency:
  - 205 hours per year, with PV capacity based on the 2020 CELT forecast
  - 454 hours per year, with PV capacity based on the 2021 CELT forecast

Minimum Load, Generators as Sync. Condensers

- In the mid-day minimum load condition, four gas-fired plants near the fault location were left online at 0 MW, acting as synchronous condensers
- Amount tripped due to SEMA/RI SLG fault with breaker failure: 1,620 MW
  - Slight improvement from original mid-day minimum load results
  - 235 MW of DER no longer tripping



Green dots: DER tripped in this simulation
Blue dots: DER tripped in the original minimum load case (on slide 13), but not in this simulation

Other Mitigation Strategies for DER Tripping

- If newer DERs are operated with voltage control capability, could they support distribution voltage during/after the fault and keep older DERs from tripping?
  - Simulations showed almost no difference in IEEE 1547-2003 DER tripping with IEEE 1547-2018 DER modeled with dynamic voltage control capability
- Will DER inverters eventually be replaced with inverters that comply with IEEE 1547-2018 and ISO-NE Source Requirements Document?
  - Virtually all DER tripped has inverters installed under IEEE 1547-2003
  - Replacement may occur gradually over time, eventually eliminating the risk of large amounts of DER tripping during most transmission system faults
  - However, the transmission system must be planned and operated securely in the meantime, before this replacement occurs
  - Even IEEE 1547-2018 DER will still enter temporary power reduction; further analysis is required to determine whether thousands of MW of DER temporarily reducing power poses a reliability risk

Other Mitigation Strategies for DER Tripping

- Further analysis of the addition of synchronous condensers to the transmission system is ongoing
- Synchronous condensers remote from DER (i.e. on the 345 kV system) do not seem to be effective at keeping DER online
- Ongoing analysis is testing the effectiveness of synchronous condensers at locations electrically closer to DER

NEXT STEPS & TENTATIVE TPCET SCHEDULE

Further Analysis for TPCET Pilot Study

- Steady-State Analysis
  - Variations on peak load cases, reflecting generator dispatches similar to those in recent Needs Assessments
  - Mitigating measures for steady state high-voltage conditions at minimum load, following the addition of any stability-related dynamic devices
- Stability Analysis
  - Investigation into addition of synchronous condensers to reduce the amount of DER tripping for transmission system faults
  - Further investigation into acceptable megawatt limits on DER tripping

Preliminary Plans for Future PAC Presentations

- August 2021: Final PAC presentation on steady-state and stability results, proposal for new study assumptions for load, solar generation, and wind generation
- September 2021: Finalize and document new study conditions for load, solar generation, and wind generation

Questions