Eversource DER Level 3 ASO Study Preliminary Results

Developers Update

December 11th, 2020

Purpose of the Eversource Level 3 ASO Study

- Ensure the proposed DER interconnection Projects will not in aggregate cause a significant adverse impact on the reliability and operating characteristics of the Eversource transmission system, the transmission facilities of another Transmission Owner, or the system of a Market Participant, and if they do, to recommend system improvements that would eliminate the adverse impacts.
- For this purpose, the following studies were conducted:
  - Steady-state analysis to assess thermal overloads and voltage limit violations resulting from the DER interconnections
  - Stability analysis to verify acceptable model performance and to identify any violations of stability acceptability criteria following system disturbances resulting from the interconnection
  - Short-circuit analysis to assess if circuit breaker short-circuit interrupting capability limits or buswork short-circuit structural limitations are exceeded as a result of the interconnection,
  - Determination of any upgrades that are required to eliminate any thermal or voltage violations, system dynamic and transient instability, and/or degradation to transfer capability
  - SEMA and Cape only: PSCAD evaluation to verify acceptable control stability and interactions between inverter-based technologies connected to Distribution and Transmission, and acceptable DER ride-through capabilities;

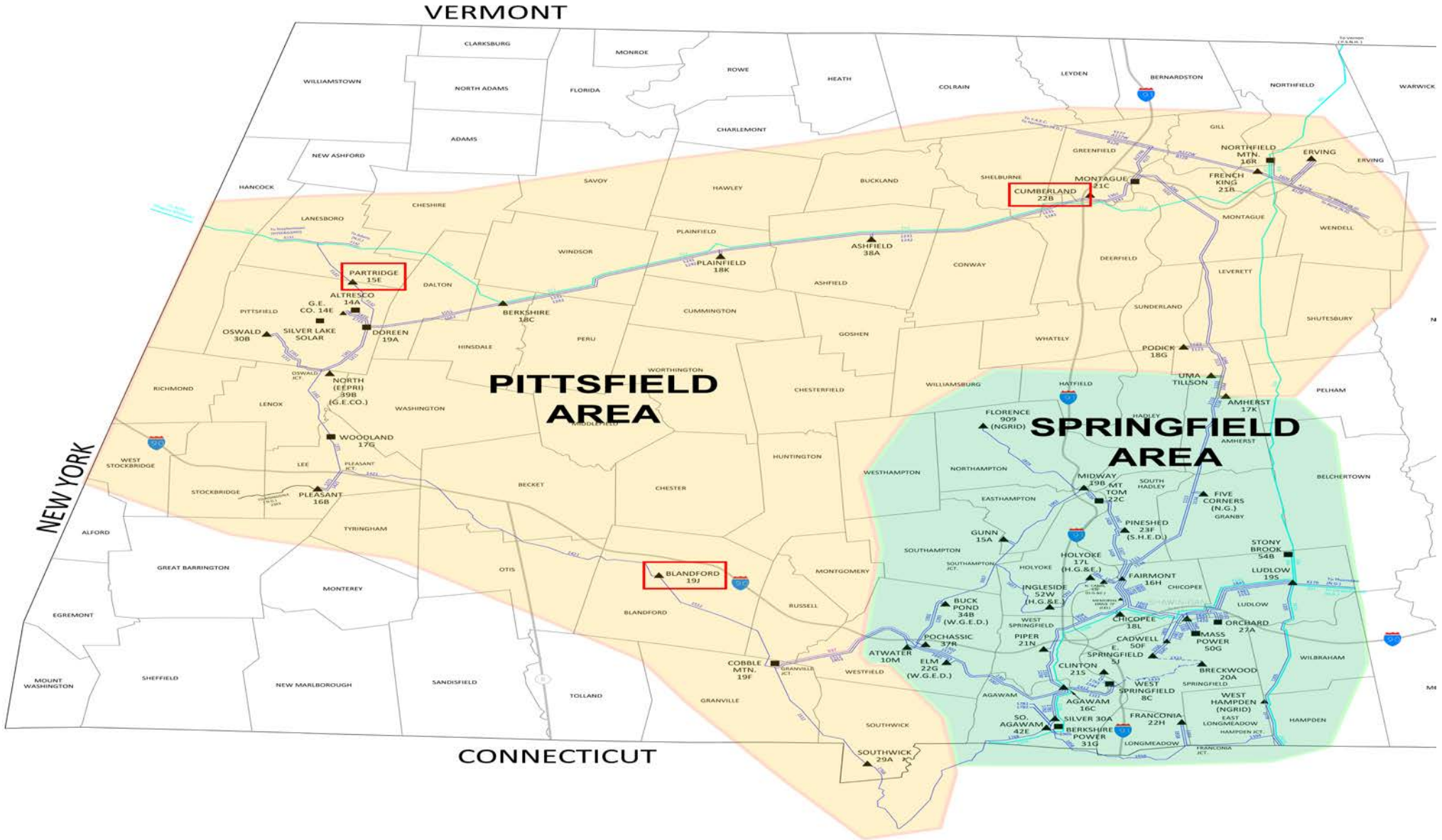
Western Massachusetts (WMA)

DER Applications Aggregated by Substation in WMA

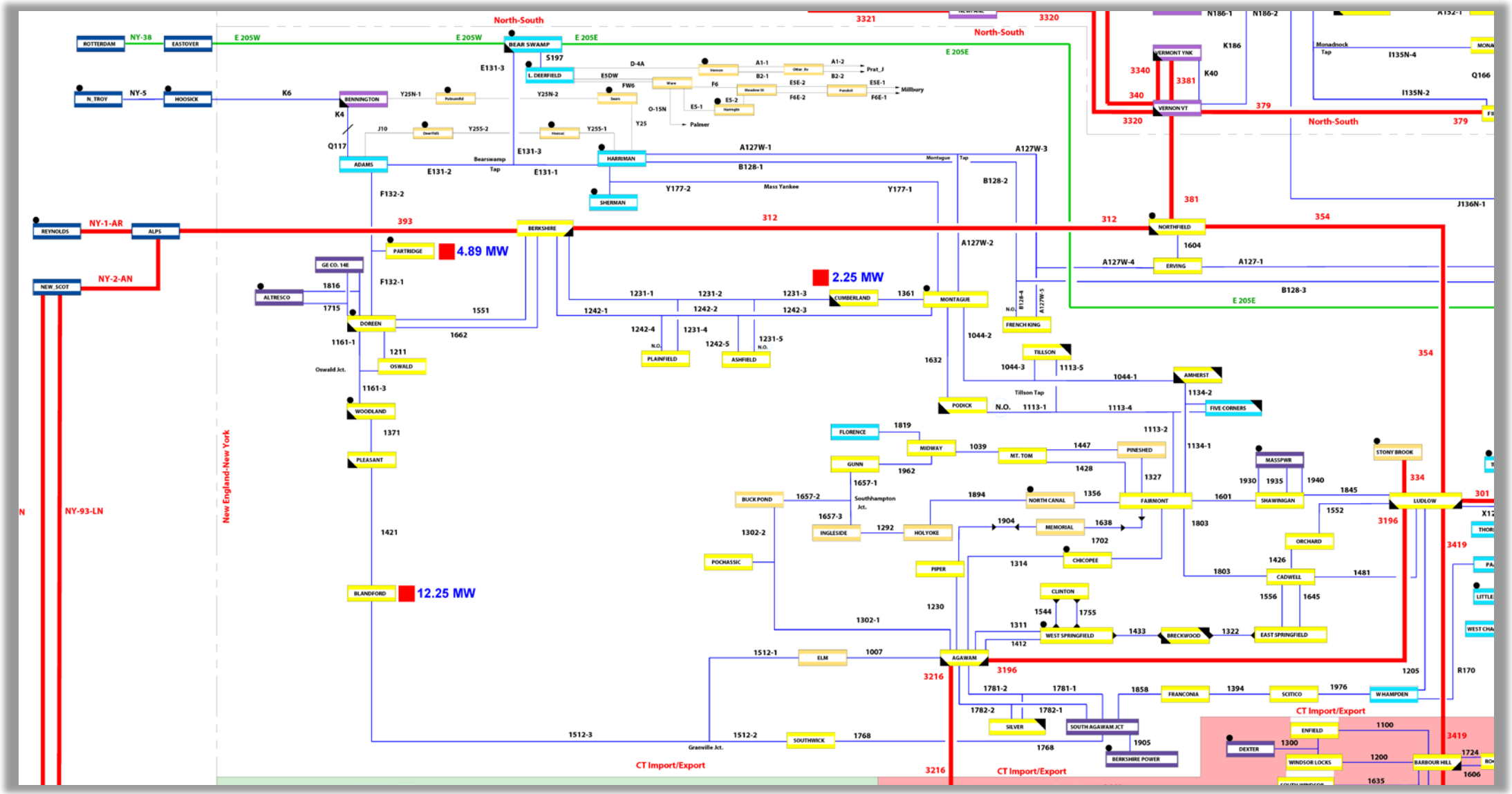
- 5 DER applications totaling 19.3 MW applied for interconnection to the Eversource Distribution System in Western Massachusetts:
  - 3 applications totaling 12.3 MW at Blandford 19J
  - 1 application totaling 4.9MW at Partridge 15E
  - 1 application totaling 2.3MW at Cumberland 22B.

ISO-NE Non-FERC Queue #	Substation	Number of Applications	Aggregate DG Capacity (MW)
989	BLANDFORD 19J	3	12.3
990	PARTRIDGE 15E	1	4.9
991	CUMBERLAND 22B	1	2.3

Geographic Location of the Proposed DER Projects in the Eversource System in WMA



System Location of the Proposed DER Projects in the Eversource System in WMA



WMA Steady State Base Cases

- Steady state base cases representing study year 2023 included the following projects
  - Transmission Upgrades
    - Westfield Reliability Project (Atwater Switching Station)
    - Montague-Amherst Reliability Project (rebuild of Lines 1044, 1632, 1113, & 1134)
  - Relevant Group Studies
    - NGRID WMA Group 1& 2 DER interconnections and associated upgrades
    - NGRID RI DER Cluster Study
- East-West and West to East stresses with NY-NE Import or Export
  - 2 peak load cases with East-West and West-East stresses.
  - 4 shoulder load cases with East-West and West-East stresses. Included are sensitivity cases with Eversource DER assumptions
  - 4 light load cases with East-West and West-East stresses. Included are sensitivity cases with Eversource DER assumptions
  - 1 minimum load case with West to East stress Eversource actual day time min load and DER assumptions
  - 11 base cases, with a total of 22 cases including pre- and post-project cases

WMA Stability Base Cases

- NC stability base cases representing study year 2023 included the following projects
  - Transmission Upgrades
    - Westfield Reliability Project (Atwater Switching Station)
    - Montague-Amherst Reliability Project (rebuild of Lines 1044, 1632, 1113, & 1134)
  - Relevant Group Studies
    - NGRID WMA Group 1& 2 DER interconnections and associated upgrades
    - NGRID RI DER Cluster Study
- Peak load and light load levels were tested.
  - 1 Peak load East-West stress
  - 2 Light load East-West and West-East stresses

Short Circuit Base Case

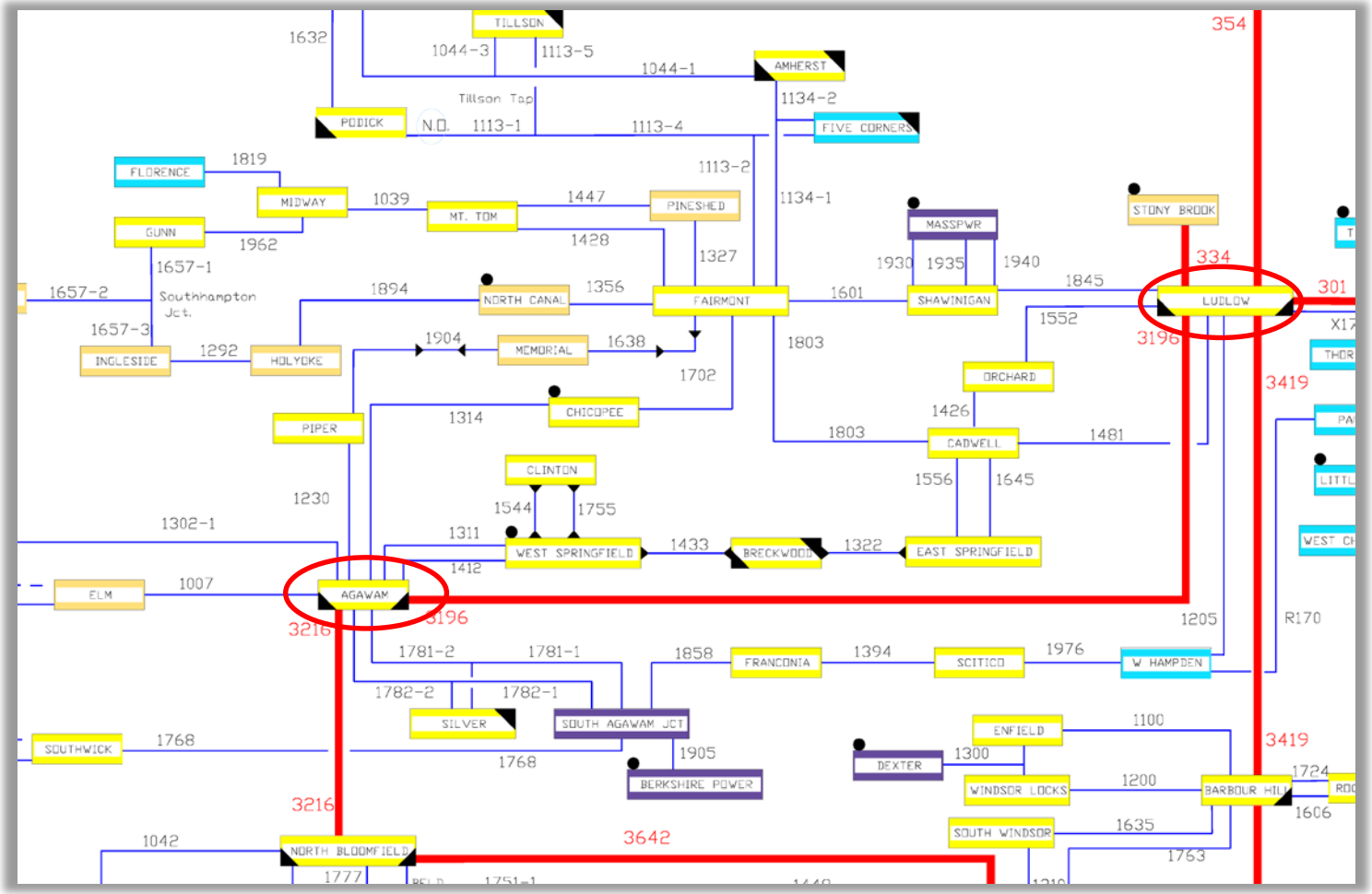
- Short circuit base case was provided by ISO-NE that includes all relevant FERC interconnection projects in the study areas.
- Existing and PPA approved DERs between 1 MW and 5 MW were aggregated by distribution bus and modeled in the pre project short circuit base case.
- The post-project case includes the DER projects under study.
- The Voltage Controlled Current Source (VCCS) model were used for all PV inverters in this study.

Preliminary Steady State Thermal and Voltage Results Summary

- The post-project N-1 and N-1-1 post-contingency thermal loadings met the Transmission System Planning criteria.
- The post-project N-1 post-contingency voltages met the Transmission System Planning criteria.
- Pre-existing N-1-1 high voltage violations at the Ludlow and Agawam 345-kV switchyards have been identified.
  - This occurred in the pre- and post-project cases for the light load, east-to-west stressed cases.

Western MA 345-kV Voltage Issue (N-1-1)

- The 345-kV switchyard voltage at Agawam substation can rise higher than criteria for certain N-1-1 events with high East-West and New England-New York transfers.
- These post-event high voltages occur before the proposed DERs are included and are not made worse when the proposed DERs are included.
- The potential high voltages can be addressed with a shunt reactor at Agawam substation that is tapped and can absorb between 50- and 100-MVAR depending on tap position.



Next Steps

- Complete study and issue final report to ISO-NE by end of December 2020
- Obtain RC approval in January of 2021
- Official ISO-NE PPA approval letters expected by end of January 2021

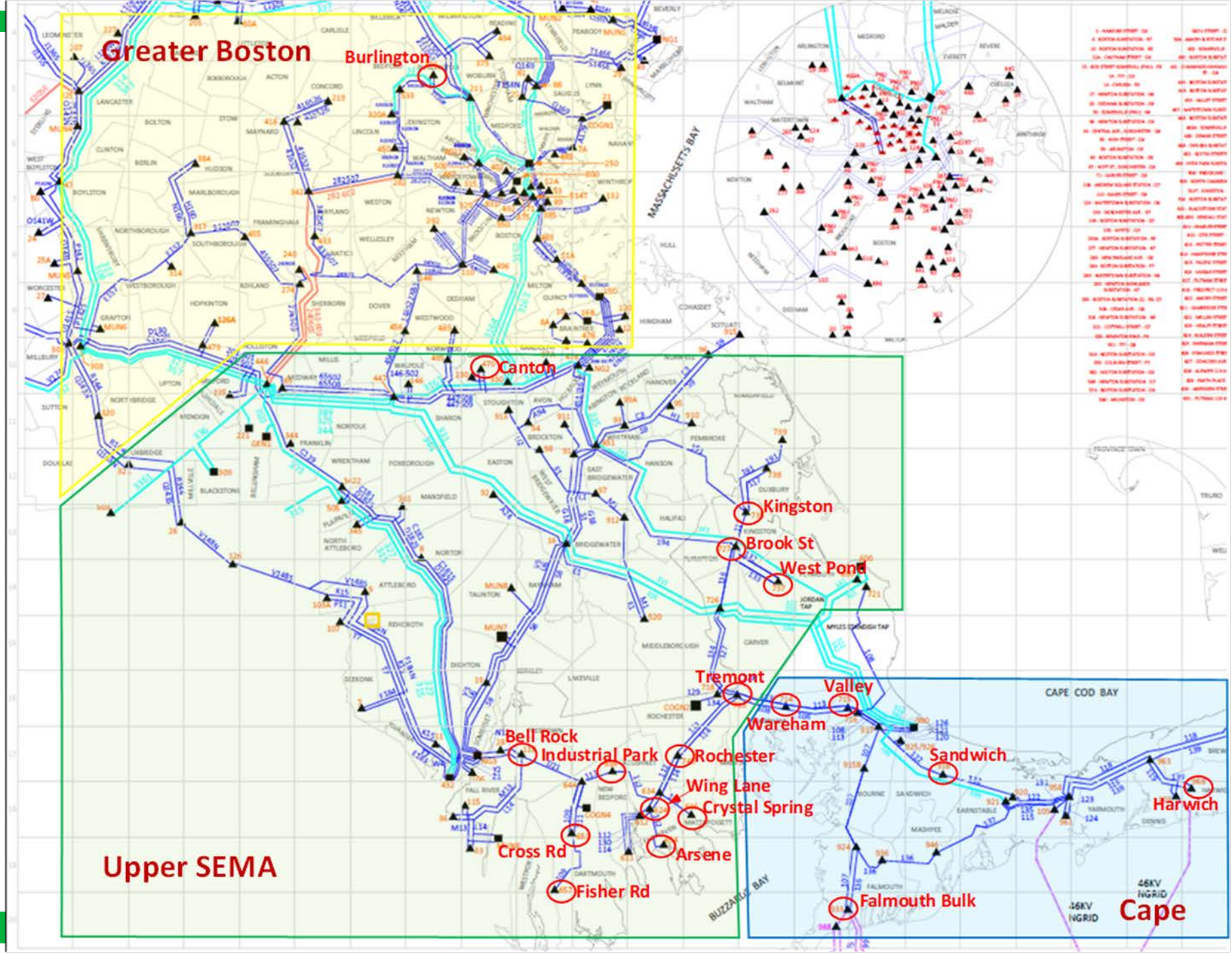
QUESTIONS?

Eastern Massachusetts (EMA)

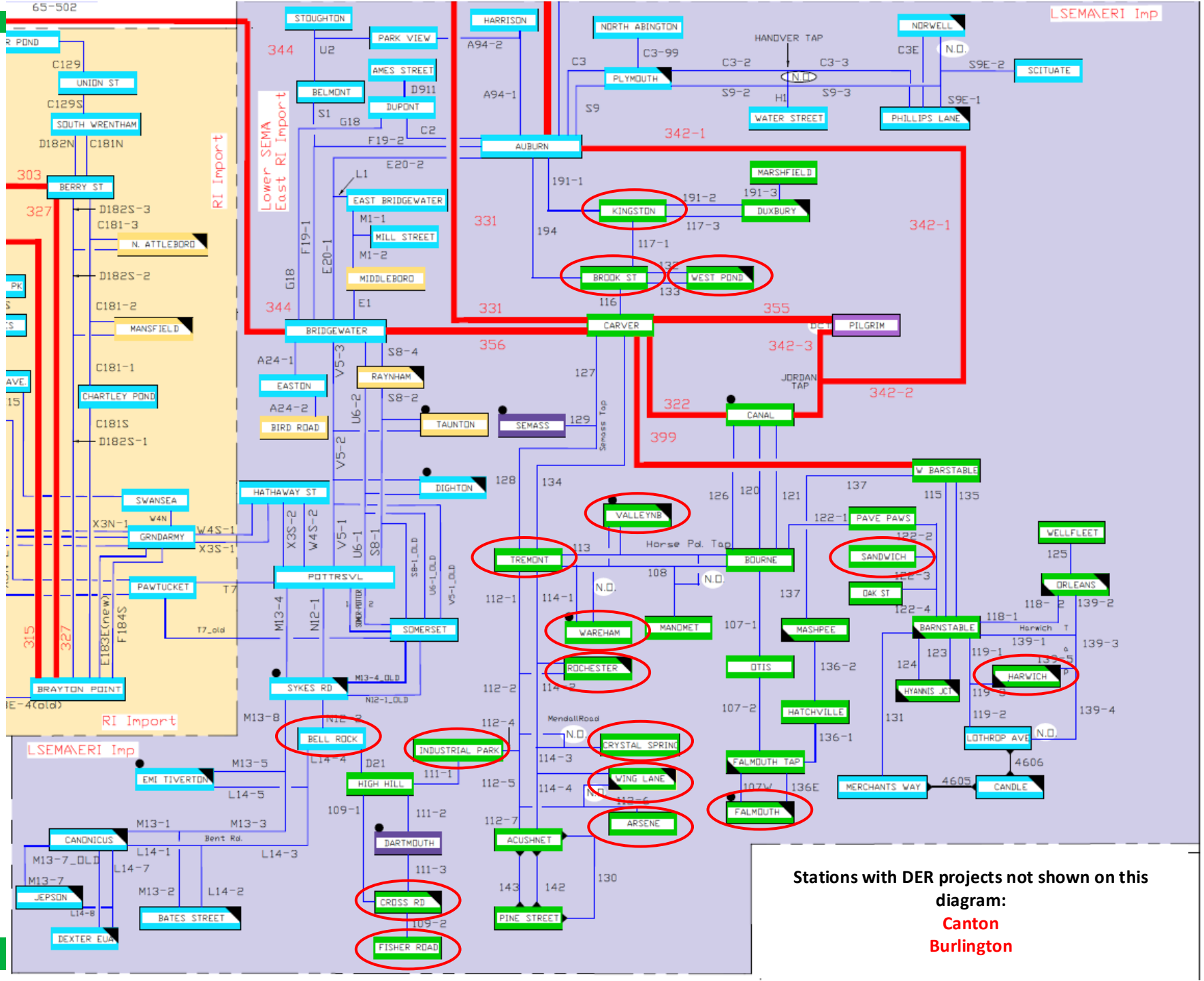
DER Applications Aggregated by Substation in EMA

ISO-NE Non-FERC Queue #	Substation	Total # of Applications	Total Aggregate Export Limit (MW)
A-Greater Boston		**1**	**5.00**
994	Burlington 391	1	5.00
B-Upper SEMA		**45**	**164.10**
992	Arsene St 654	2	7.00
1032	Bell Rock 661	3	11.99
993	Brook St 727	1	2.00
995	Canton 470	1	5.00
996	Cross Road 651	2	7.00
997	Crystal Spring 646	1	5.00
999	Fisher Road 657	5	18.20
1001	Industrial Park 636	7	27.24
1002	Kingston 735	1	2.76
1003	Rochester 745	5	16.00
1005	Tremont 713	5	17.56
1008	West Pond 737	10	34.37
1009	Wing Lane 624	2	9.99
C-Cape		**28**	**78.82**
998	Falmouth 933	2	7.99
1000	Harwich 968	1	3.15
1004	Sandwich 916	13	11.18
1006	Valley 715	2	10.00
1007	Wareham 714	10	46.51
Total		**74**	**247.92**

Geographic Location of the Proposed DER Projects in the Eversource System in EMA



System Location of the Proposed DER Projects in the Eversource System in EMA



Stations with DER projects not shown on this diagram:

Canton

Burlington

Steady State EMA Base Cases

- Steady state base cases representing study year 2022 and 2025
  - 2022 system topology with no FERC interconnections in SEMA. SEMA/RI upgrades with ISD after 2022 are excluded:
    - Mid-Cape reliability project (new 115 kV Bourne - West Barnstable line) – RSP ID#1725 – ISD 12/2023
    - Bourne station rebuild to breaker and half – Asset condition ID# 26 – ISD 12/2023
    - 114 extension project – RSP ID# 1722 and 1730 – ISD 12/2023
    - Medway loop project – RSP ID#1732 – ISD 01/2023
  - 2025 system topology with all SEMA/RI upgrades and all relevant FERC interconnections
- East-West stress with high SEMA/RI generation and West-East stress and with high SEMA/RI Import
  - 3 peak load cases for each study year with East-West and West-East stresses including BESS charging and discharging cases.
  - 3 shoulder load cases for each study year with East-West and West-East stresses. Sensitivity cases with Eversource DER assumptions
  - 2 light load cases for each study year with high SEMA generation and sensitivity cases with Eversource DER assumptions
  - 2 minimum load cases for each study year. Minimum interface transfer level and generation in SEMA. Sensitivity cases with Eversource actual day time min load and DER assumptions
  - Total of 40 cases including pre- and post-project cases.

Stability EMA Base Cases

- NC stability base cases representing study year 2022 and 2025
  - 2022 system topology with no FERC interconnections in SEMA. SEMA/RI upgrades with ISD after 2022 are excluded:
    - Mid-Cape reliability project (new 115 kV Bourne - West Barnstable line) – RSP ID#1725 – ISD 12/2023
    - Bourne station rebuild to breaker and half – Asset condition ID# 26 – ISD 12/2023
    - 114 extension project – RSP ID# 1722 and 1730 – ISD 12/2023
    - Medway loop project – RSP ID#1732 – ISD 01/2023
  - 2025 system topology with all SEMA/RI upgrades and relevant FERC interconnection projects with stability models: QP624, QP700 and QP726.
- Peak load and light load levels were tested.
  - Peak load West-East stress with low generation dispatched in SEMA with limited voltage support.
  - Battery charging was studied with peak load West-East case.
  - Light load East-West stress with high generation dispatched in SEMA and West-East stress.
- BPS cases with dispatches specified by ISO-NE were used for Bulk Power System (BPS) and Extreme Event testing.

Short Circuit Base Case

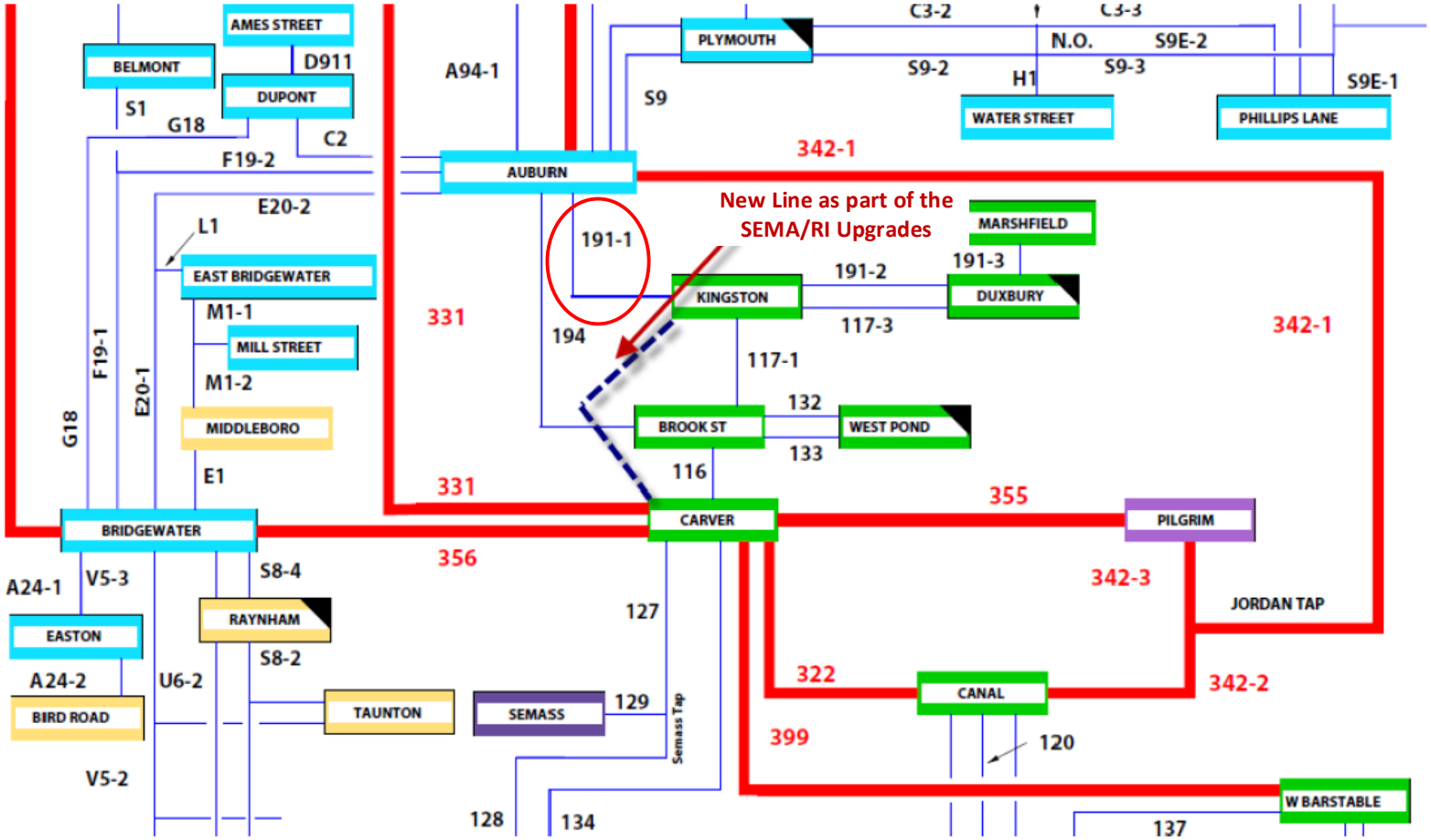
- Short circuit base case was provided by ISO-NE that includes all relevant FERC interconnection projects in the study area.
- Existing and PPA approved DERs between 1 MW and 5 MW were aggregated by distribution bus and modeled in the pre project short circuit base case.
- The post-project case includes the DER projects under study.
- The Voltage Controlled Current Source (VCCS) model were used for all PV inverters in this study.

Preliminary Steady State Results Summary

- The post-project N-1 post-contingency thermal loadings met the Transmission System Planning criteria.
- Post-project N-1-1 overload on the 115 kV 191 line has been identified for 2025 summer peak, shoulder and light load, east-to-west stressed cases.
- Pre-existing N-1 and N-1-1 high voltage violations in the Cape area have been identified in the minimum load cases.
- Preliminary short circuit analysis results indicate that no breakers were overdutied.

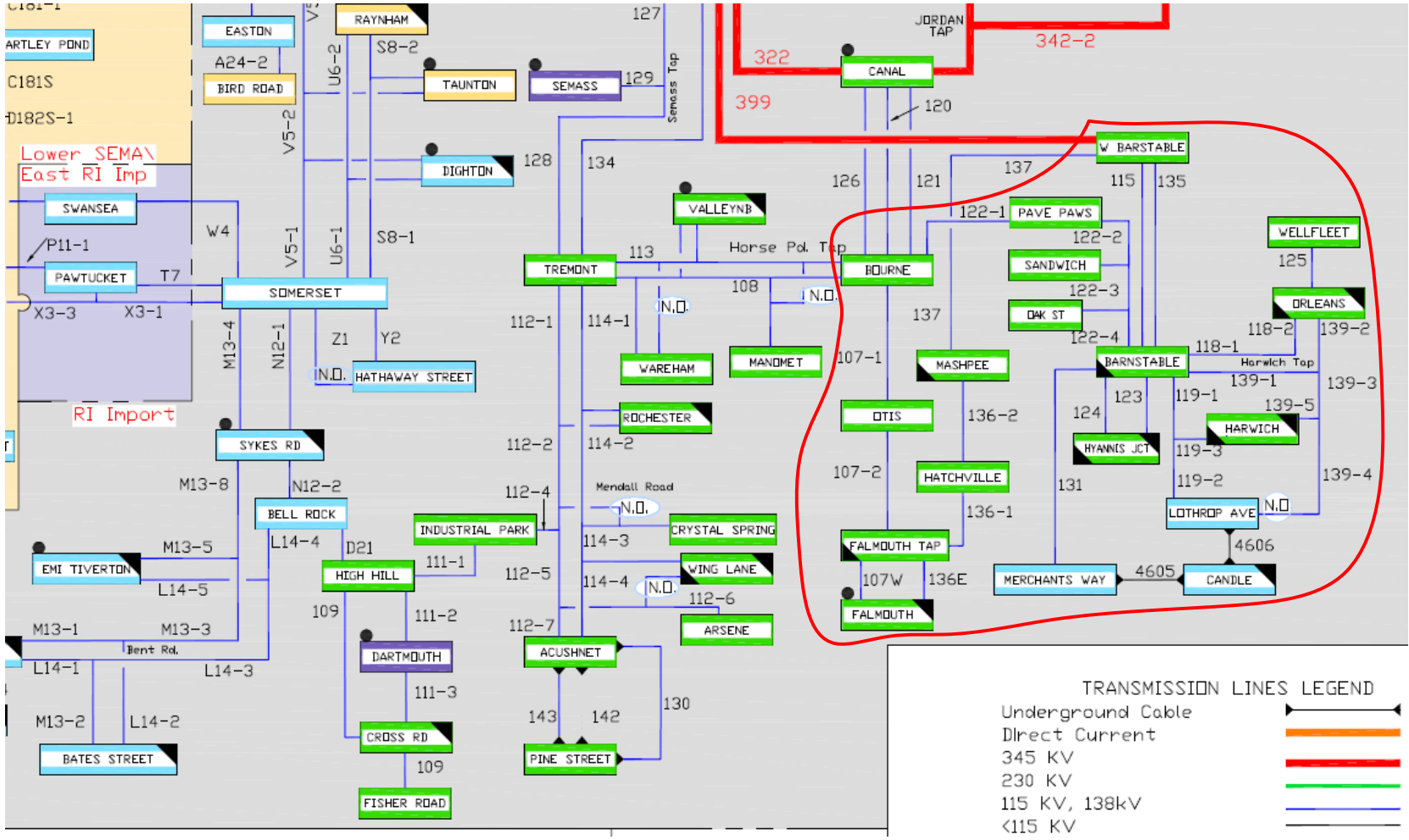
N-1-1 Thermal Overload in EMA

- The 115 kV 191-1 line (Auburn St. – Kingston) was found overloaded under N-1-1 conditions at various load levels in the 2025 system topology.
- Addition of about 243MW of DER in SEMA and Cape caused this overload in system conditions with high FERC interconnection projects including Offshore Wind in SEMA and Cape.
- Potential solution is to reconductor this 191 line. Eversource is evaluating scope of work.



High Voltage Issue in EMA in Minimum Load Cases

- Pre-existing high voltage issues in Cape area were seen under N-1 and N-1-1 conditions in both 2022 and 2025 minimum load cases.
- Operations has also observed existing high voltage issues in the Cape area.
- Potential solution is to add reactive devices in Cape. Technology types (reactors, STATCOM or synchronous condensers) and locations are being investigated.



Next Steps

- Complete all the steady state, stability and short circuit analyses by the end of December 2020.
- Issue final report of the Greater Boston area to ISO-NE by end of December 2020.
- Obtain RC approval for the project in Greater Boston area in January 2021.
- Official ISO-NE PPA approval letter expected by end of January 2021
- Complete the PSCAD study for SEMA and Cape areas by the end of April 2021.
- Obtain RC approval for the projects in SEMA and Cape areas in May 2021.

Complexity of PSCAD Study

- **Quality of the DER inverter PSCAD models**: PSCAD models are more detailed than standard PSS/E models for stability analysis. They are usually developed by the inverter manufacturers and include proprietary information of the control systems. Not all PSCAD models are created equal thus it takes more time to test and validate each PSCAD model of each type of inverters. It has been an intensively iterative process to work with developers to resolve the deficiencies present in many of the PSCAD models they provided. It is expected to take up to 2 months or longer to fully repair and validate these models. Up to date we are still waiting for responses from some of the developers to correct their models.
- **Run-time of PSCAD simulations**: A PSCAD study evaluates Electromagnetic Transients within a very short time frame (in the order of milliseconds) thus requires small timesteps (in the order of microseconds). Therefore PSCAD simulations can take a long time even on a computer with extensive computational power. For example, a 20-sec simulation on a case of 450 buses takes 2.5 hours for a 64-core computer with parallel processing.
- **Determination of the study scope**: Steady state and stability analyses results provide important insights on system constraints and are inputs to the PSCAD study. In order to more efficiently scope out the PSCAD study we have been focusing on the steady state and stability analyses. Setting up the PSCAD cases is also complicated because there is no PSCAD case available for the study area with all the required DER inverter models and other inverter-based devices.
- **Availability of PSCAD models of ISO-NE queued projects due to NDA issues**: ISO-NE requested several FERC queued interconnection projects in the SEMA area to be included in the PSCAD study cases. ISO-NE is not able to share the model information with Eversource directly due to NDAs between ISO-NE and the developers/manufacturers. Eversource made initial requests for PSCAD models with these developers in May and we have received the models recently with help of ISO-NE.
- **Iterative PSCAD and PSS/E simulations**: If the PSCAD study results do not match the PSS/E study results or changes are made in PSCAD studies to address any issues, PSS/E steady state and stability simulations will need to be re-tested.

QUESTIONS?