How New England Plans and Operates the Grid to Deal with Large-Source Contingencies

ESIG Presentation

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Key Points

- New England System Planners and Operators have a history of successfully managing potential large-source contingencies as generation resources trended larger and posed risks beyond the New England region
- This became more focused with the arrival of NERC compliance standards and the potential for Interconnection Reliability Operating Limit exceedance (IROL)

The "Way Back" Time Machine

- It's the 1960s
- Annual load growth in some areas was as high as 10%
- Utilities were actively encouraging electrification of society, e.g., many utilities had company stores selling electrical appliances
- Most of the load along the East Coast was between Washington, DC and Boston
- It was the dawn of the nuclear power industry
- Bigger was better, especially with nuclear, and the transition from smaller Boiling Water Reactors (BWR) to larger Pressurize Water Reactors (PWR) had begun

The “Way Back” Time Machine

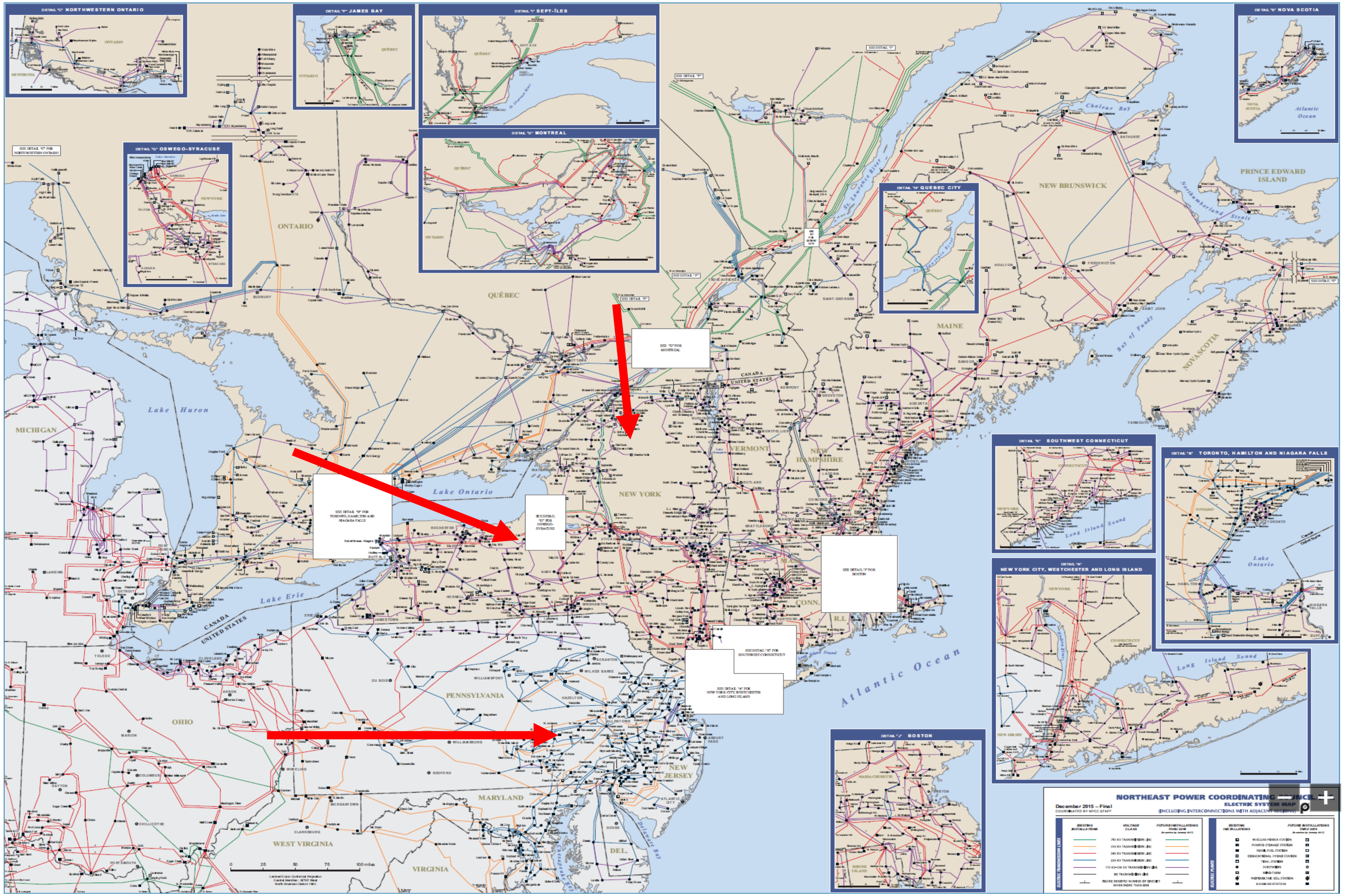
- The newer PWRs were ≈1250MW gross capability with ≈50MW of station service (1200MW net output)
- At the peak of nuclear development nine plants were operating in New England, with plans to build at least another eleven in the region
- NYISO and PJM had similar ambitious plans for additional nuclear plants
- The 1250MW PWR was about the maximum size for these plants
- Planners were designing systems to accommodate a slew of plants this size in terms of transmission and reserve requirements

The "Way Back" Time Machine

- The less efficient more expensive generators on the East Coast were older facilities built in the 1920s, 30s and 40s located in or near the big cities
- NYISO would typically buy cheaper hydro and coal generation from Ontario and Quebec before committing their less efficient resources
- PJM would typically buy cheaper coal generation from AEP and points west before committing their less efficient resources
- Therefore, the bulk power system (BPS) would start loading in a west-to-east direction at the start of the morning load pickup
- In general, these west-to-east BPS paths would be fully loaded with economic transfers a high percentage of the time

The "Way Back" Time Machine

General Power Flow Directions



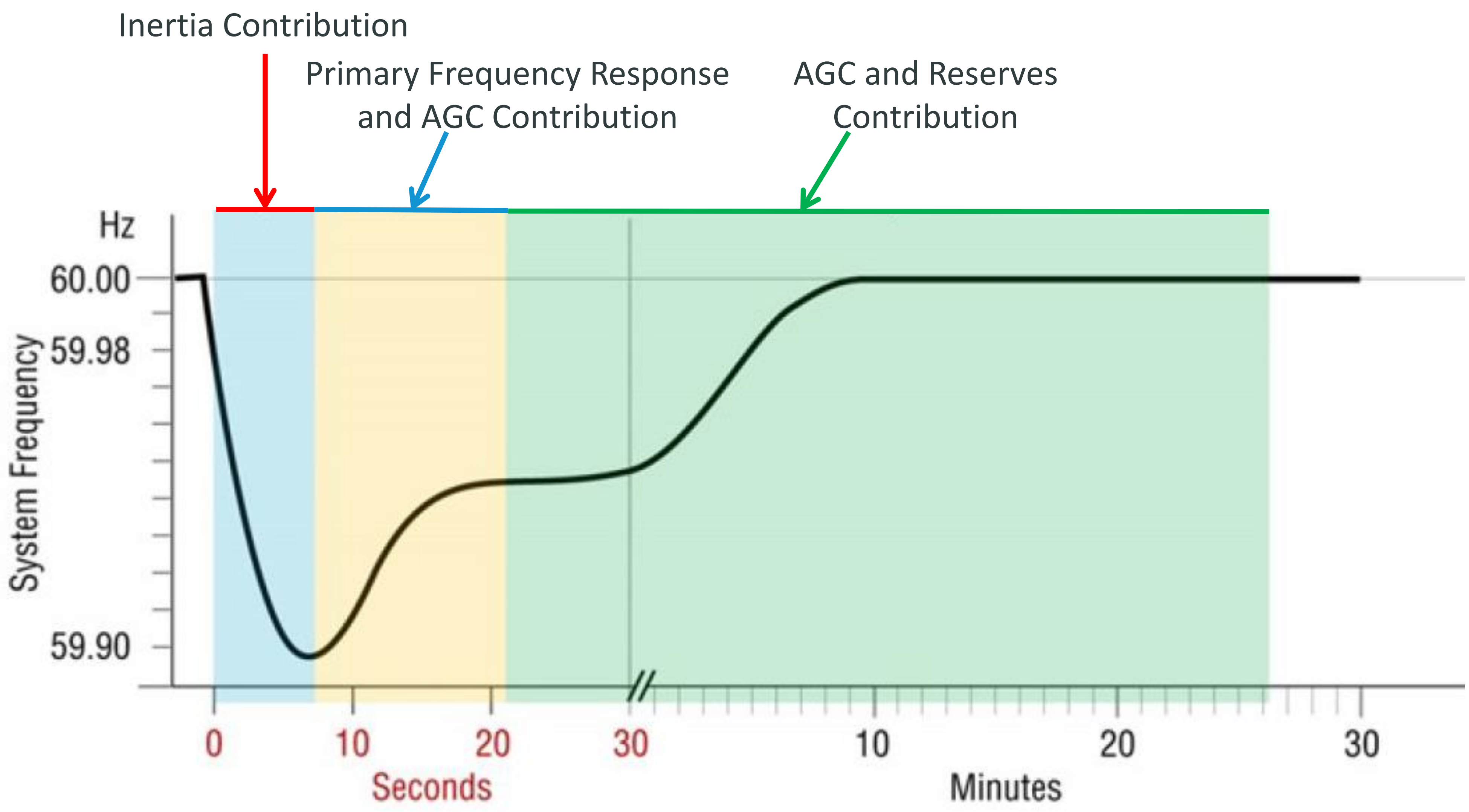
Engineering 101

- Loss of source requires replacement MWs to rebalance the system and restore frequency (ERSWG work)
- After loss of a resource, the system relies on inertia to determine the initial rate of decline in frequency, i.e., the rate of change of frequency (ROCOF), then governor response to begin restoring frequency, then generators on Automatic Generator Control (AGC – 5 second dispatch signal in N.E.) and lastly replacement reserves (10 and 30 minute resources in N.E.)

Engineering 101

- The exact timing of governor response, AGC and operational reserves is dependent on the resource dispatch at any given time based on their physical characteristics and equipment settings, also regional differences
- Inertial response is supplied by all the online resources within the Eastern Interconnection (EI)

Engineering 101



Engineering 101

- Rule of thumb: upon loss of a large source in New England ≈9% to 12% (dispatch dependent) of the inertial response will be provided by the New England and Maritime (New Brunswick, Nova Scotia, Price Edward Island) resources
- Therefore, the rest of the inertial response has to come from the resources throughout the remaining EI
- Those MWs have to flow on the same BPS that is already potentially loaded with economic pre-contingent flows
- Therefore, planners designed a system for “worst case” scenario to withstand loss of a 1250MW nuclear resource on top of a fully loaded BPS across the Northeast

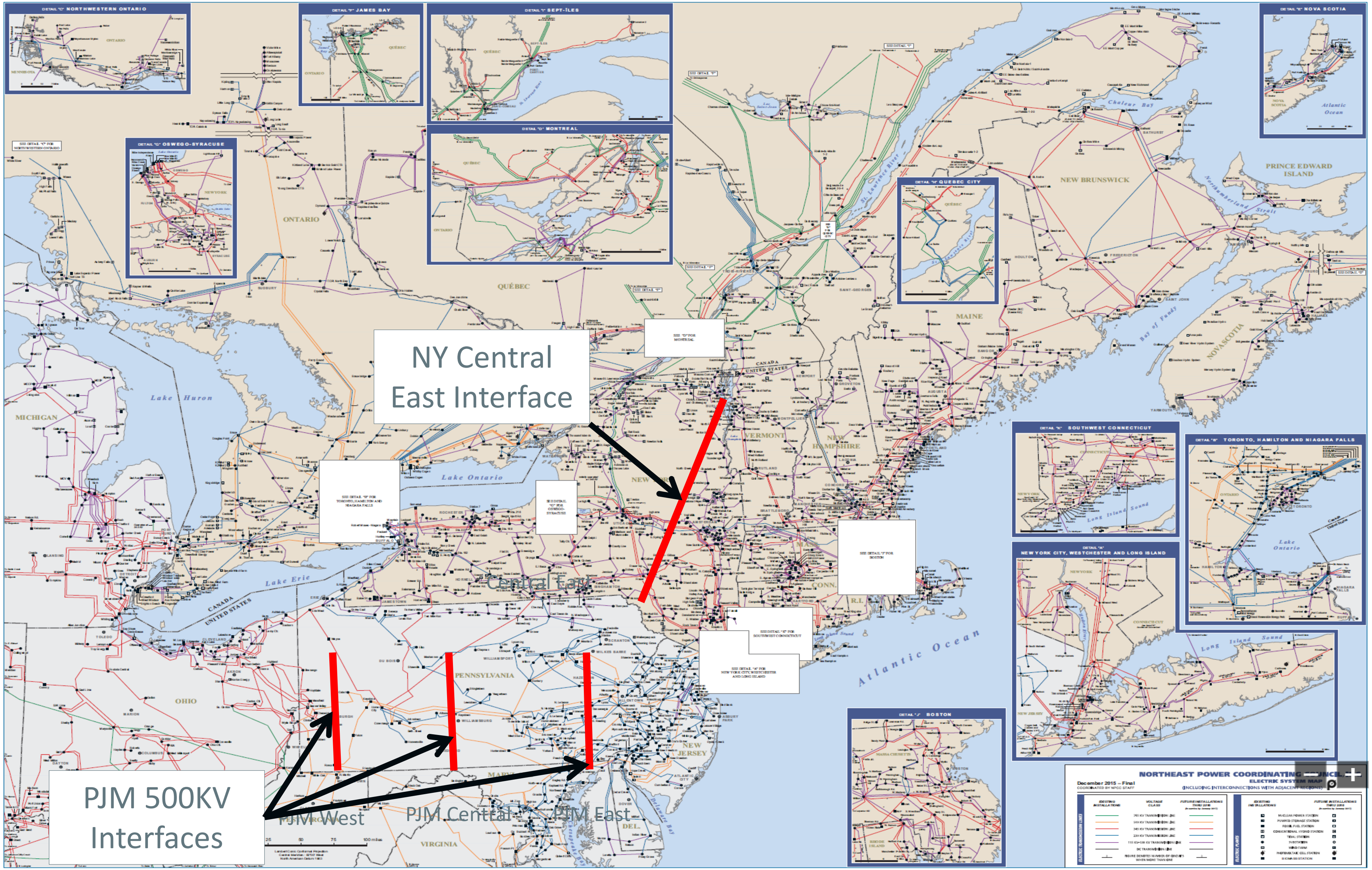
Criteria

- All three Reliability Coordinators (RC) have criteria for the thermal, voltage and stability performance of their respective systems
- Criteria are a combination of NERC, Regional and individual RC reliability standards (can be equal to, or more stringent than, NERC criteria)
- The NYISO system is generally limited by the transient voltage response of the 345kV system to faults
- The PJM system is generally limited by the delta in voltage on the 500kV system for contingencies

Criteria

- In NYISO, one of the dominant interfaces is Central East
  - Power transfers from Ontario, western NYISO generation and Quebec all flow over the interface
  - NYISO determines the maximum transfer capability based on transient voltage criteria
  - The system is operated up to the transfer limit based on loss of a 1250MW resource “east” of the interface
- In PJM, the dominant interfaces are the west, central and east 500kV interfaces
  - Power transfers from points west all flow over these interfaces
  - PJM determines the maximum transfer capability based on a delta V ≤ 5% from pre- to post-contingent state
  - The system is operated up to these transfer limits, which support the loss of a 1250MW resources “east” of the interfaces

Criteria


NY Central East Interface
PJM 500KV Interfaces
PJM West
PJM Central
PJM East
Central East
NORTHEAST POWER COORDINATING COUNCIL
ELECTRIC SYSTEM MAP
December 2015 - Final

The Dilemma

- In the late 1970s New England began exploring the possibility of interconnecting with Quebec to import hydro from the James Bay Complex
- Systems were somewhat incompatible so had to be a DC tie not AC
- “Bigger is better” so a 2000MW HVDC tie at Sandy Pond in Massachusetts was built and commissioned in 1986
- Soon became apparent that operation at levels above 1250MW would be problematic because of the potential large source loss issue
- PJM, NYISO and ISO-NE agreed to operational protocols in 1991, currently memorialized in respective Tariffs: http://www.iso-ne.com/regulatory/ferc/filings/2007/feb/er07-231-001_2-12-07_resubmission_phase_ii_import_procedures-pjm_nyiso_iso.pdf

The Solution

- ISO-NE agrees to not operate resources in New England above the 1250MW level unless NYISO and PJM have “margin” on their limiting interfaces
- Margin is defined as the “unused” amount of transfer capability between the limit and the actual flow in real-time
- NYISO and PJM agree to provide ISO-NE information regarding available “margin” in real-time via Inter-Control Center Communications Protocol (ICCP)
- ISO-NE agrees to operate the large source loss appropriately based on available “margin”

The Solution

- The ISO-NE operator contacts the NYISO and PJM operators to obtain permission to use margin on those systems
- The NYISO and PJM operators verbally communicate the margin that ISO-NE is authorized to use
- The ISO-NE operator enters these values into the appropriate EMS displays for use by security constrained dispatch
- The ISO-NE operator coordinates this schedule with the HVDC operators, applicable power plant operators (GO) and the local Transmission Operator Control Centers (TOP)

Future Considerations

- It’s not always about location, location, location………..what about size?
  - Development of wind renewables in New England is growing rapidly
  - This growth is largely due to federal and state incentives
  - The physical location and interconnection points are a major consideration, however per this presentation, MW size and technical capability of the facilities is just as critical as location
  - This includes internal New England interfaces as well as external New England considerations

Future "External" Considerations

- There are important size considerations when adding large scale inverter resources (or any resource):
  - Exposure to a *single transmission contingency, e.g., loss of a cable, transformer, transmission line, etc.* that results in loss of more than 1200MW
  - At what point does this create a negative impact on traditional transfers across critical external NYISO/PJM interfaces (becomes dependent on margins)?
  - Does the risk of this type of event increase significantly during high maintenance periods when there are other significant generation and transmission facilities OOS (N-X)?
- Developers of large-scale resources, including renewables, whether on-shore or off-shore, should consider how these potential issues may affect their ability to operate as they plan to interconnect to the region's electric grid

Future "Internal" Considerations

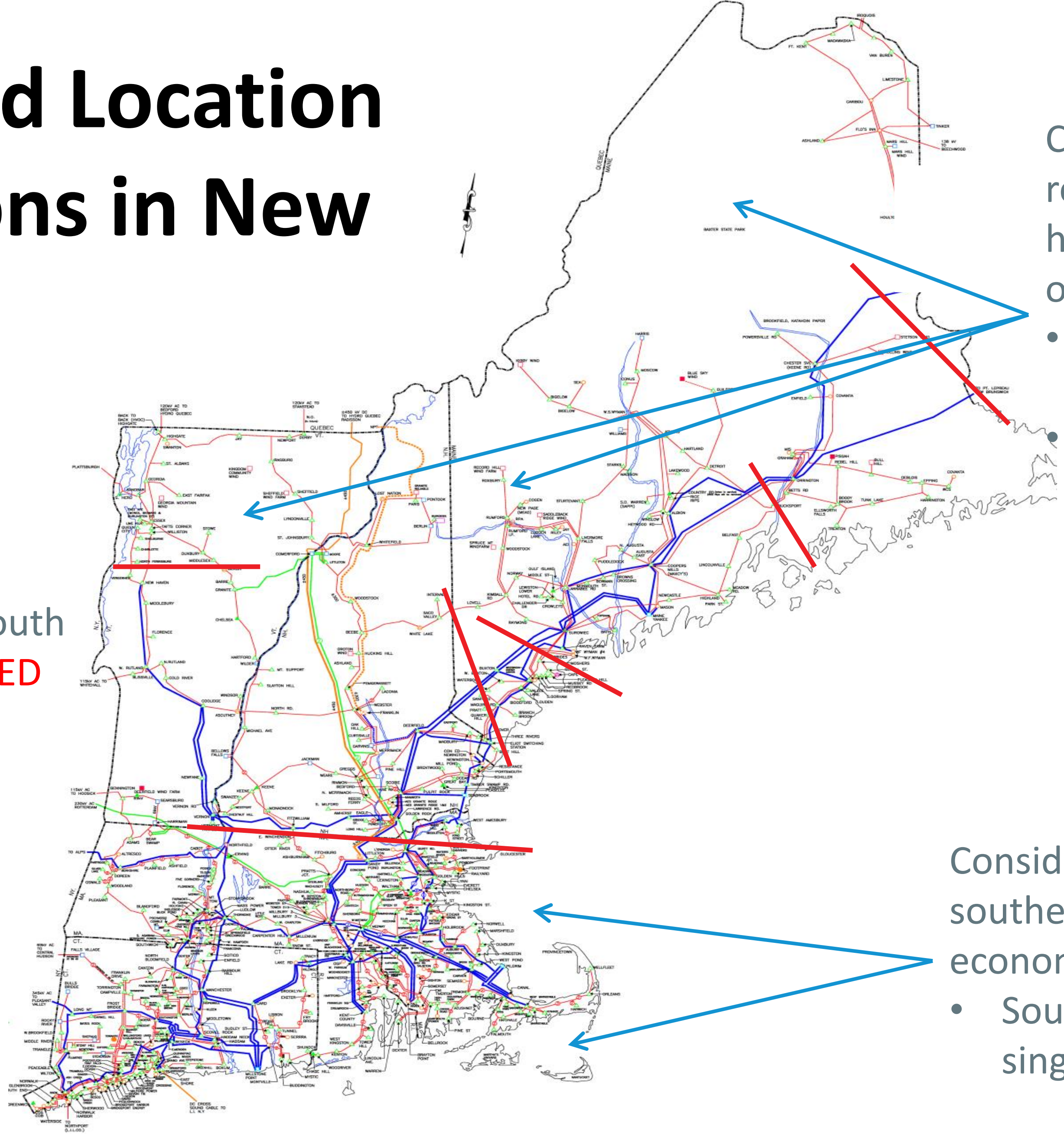
- New England locational considerations for the addition of large scale inverter resources (or any resource):
  - New England has several major internal transmission interfaces that are prone to congestion
  - Several of these restrictive interfaces are in a north to south direction from the Canadian border toward the load pockets in eastern Massachusetts and Connecticut
  - Addition of land based wind resources north of these constrained interfaces can potentially exacerbate congestion issues
  - Addition of off-shore wind resources connected to the BPS north of these constrained interfaces can potentially exacerbate congestion

- Developers of large-scale resources, including renewables, whether on-shore or off-shore, must consider the potential interaction with relevant internal N.E. transmission constraints on their ability to operate as they plan to interconnect to the region's electric grid

Future “Internal” Considerations

- Technical capability considerations, does the addition of large scale inverter resources:
  - Degrade the inertial and governor response in the Northeast due to displacement of existing synchronous machines (worse at light loads)?
  - Negatively impact the voltage and reactive performance of the bulk power system (SVCs, STATCOMs or sync condensers required)?
  - Align with recent FERC rulings on primary frequency response, reactive support and ride through requirements?
- Developers of large-scale resources, including renewables, whether on-shore or off-shore, should consider how these potential issues may affect their ability to operate as they plan to interconnect to the region’s electric grid

General Wind Location Considerations in New England



Typically limited North to South Interfaces highlighted in RED

Considerations: connecting in remote areas of northern N.E. could have negative economic impact a on project if:

- Source loss exceeds 1200MW for single point of failure, or
- Resource is “behind” constrained internal interfaces

Considerations: connecting to BPS in southern N.E. could have negative economic impact on a project if:

- Source loss exceeds 1200MW for single point of failure

Questions?