JUNE 19, 2013 | WESTBOROUGH, MA

New England Regional System Plan (RSP13) Representative Future Locational Forward Reserve Requirements

Planning Advisory Committee Meeting

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RESOURCE ADEQUACY

Special Note

- This forecast of representative future Locational Forward Reserve Market (LFRM) requirements is for information purposes only
  - **THESE ARE INDICATIVE VALUES, NOT THE VALUES THAT WILL BE PROCURED IN THE MARKET**
- Actual market requirements will be calculated prior to each procurement period according to Section III 9.2.3 of Market Rule 1

Representative Future Requirements

Area/Improvement	Market Period[a]	Range of Fast-Start Resources Offered into the Past Forward Reserve Auction (MW)[b]	Representative Future Locational Forward Reserve Market Requirements (MW)	
			Summer (Jun to Sep)[c]	Winter (Oct to May)[c]
Greater Southwest Connecticut[d]	2013	199-515	0[e]	To-be-updated
	2014		0	0
	2015		0	0
	2016		0	0
	2017		0	0
Greater Connecticut [f,g] **Greater Springfield Reliability Project (GSRP)**	2013	659-1,563[h]	747[e]	To-be-updated
	2014		100 to 700	0
	2015		200 to 800	0
	2016		300 to 900	0
Interstate Reliability Project (IRP) of the New England East–West Solution (NEEWS)[f]	2017		0 to 600	0 0
NEMA/BOSTON[g,i]	2013	0-441	0[e]	To-be-updated
	2014		0 to 150	0
	2015		0 to 200	0
	2016		0 to 250	0
Reflecting impact of Footprint generation	2017		0 to 300 0 with Footprint in-service	0 to 100 0 with Footprint in-service

* To-be-updated – values will be updated by RSP13 publication

Footnotes for Prior Table

(a) The market period is from June 1 through May 31 of the following year.

(b) These values are the range of the megawatts of resources offered into the past forward-reserve auctions. The amount offered into the auctions for BOSTON decreased in recent years as the reserve requirements for the market decreased. A summary of the forward-reserve offers for the past auctions is available at http://www.iso-ne.com/markets/othrmkts_data/res_mkt/summ/index.html.

(c) “Summer” means June through September of a capability year; “winter” means October of the associated year through May of the following year (e.g., the 2013 winter values are for October 2013 through May 2014). The representative values show a range to reflect uncertainties associated with the future system conditions.

(d) The assumed N−1 and N−1−1 values to reflect transmission import limits into Greater Southwest Connecticut are 3,200 MW and 2,300 MW, respectively.

(e) These values are actual locational forward-reserve requirements. The projections of the requirements for future years are based on assumed contingencies.

(f) For Greater Connecticut, the assumed import limits reflect an N−1 value of 3,050 MW and an N−1−1 value of 1,850 MW with the Greater Springfield Reliability Project in service. These limits are assumed to change to N-1 value of 2,800 MW and an N-1-1 value of 1,600 MW when the 345 kV Lake Road-Card Line is in service in 2017.

(g) In some circumstances when transmission contingencies are more severe than generation contingencies, shedding some nonconsequential load (i.e. load shed that is not the direct result of the contingency) may be acceptable.

(h) These values include resources in Greater Southwest Connecticut.

(i) The assumed N−1 and N−1−1 values reflecting transmission import limits into BOSTON are 4,900 MW and 3,700 MW, respectively. These limits are assumed to change to 4,850 MW, and 4,175 MW in 2014 to reflect the impacts of the retirement of Salem Harbor units #1–#4 and the North Shore Upgrade. The operating-reserve values for BOSTON would be lower with transmission upgrades or without consideration of the common-mode failure of Mystic units #8 and #9 that were assumed to trip up to 1,400 MW because of exposure to a common failure of the fuel supply to the units. The 2017 values for NEMA/Boston also show the forward reserve requirements assuming that Footprint Power, 674 MW, will be in-service by June 2016.

Simulation Results Summary and Observations

- Greater Southwest Connecticut Reserve Zone
  - No zonal reserve requirements are expected for both summer and winter for the study period
- Greater Connecticut Reserve Zone
  - Reserve requirements are expected in the range of 0 – 900 MW for the summer; no reserve requirements are expected for the winter period
    - In-service of Greater Springfield Reliability Project (GSRP) of NEEWS helps to reduce the reserve requirement by increasing the N-1 limit and the External Reserve Support
    - Interstate Reliability Project (IRP) of NEEWS will help to reduce the reserve requirement by increasing the N-1 limit and the External Reserve Support by ~500 MW

Simulation Results Summary and Observations, *cont.*

- NEMA/BOSTON Reserve Zone
  - Up to 300 MW of operating reserve requirement is expected for the summer, and up to 100 MW for the winter
  - Footprint generation, when in-service, would help reduce the local reserve requirements

Operating Reserve Requirements Background

- Background information and the scope of work were presented to PAC on April 24, 2013
  - http://www.iso-ne.com/committees/comm_wkgrps/prtcpnts_comm/pac/mtrls/2013/apr242013/a4_rsp13_resource_adequacy_and_related_studies.pdf

- Real-time operating-reserve capacity must be available to respond to system contingencies. Typical contingencies considered are
  - Loss of a supply source, such as a generator
  - Loss of a transmission element, such as a 345 kV transmission line
  - In certain circumstance, loss of multiple elements, such as two lines, a line and a generator, or several generators in a station that are vulnerable to a common-mode failure

Operating Reserve Requirements Background, *cont.*

- Reliability standards, criteria, and procedures require the New England power system be planned and operated to protect and recover from specific types of network contingencies
  - NERC Standard BAL-002-0 Disturbance Control Performance
    - http://www.nerc.com/files/BAL-002-0.pdf
  - NPCC Regional Reliability Reference Directory #5, Reserve
    - https://www.npcc.org/Standards/Directories/Forms/Public%20List.aspx
  - ISO New England Operating Procedure 8, Operating Reserve and Regulation
    - http://www.iso-ne.com/rules_proceds/operating/isone/op8/index.html
  - ISO New England Operating Procedure No. 19, Transmission Operations
    - http://www.iso-ne.com/rules_proceds/operating/isone/op19/op19_rto_final.pdf
- Useful reference on operating reserve requirements
  - ISO New England Operating Reserves White Paper
    - http://www.iso-ne.com/pubs/whtpprs/operating_reserves_white_paper.pdf

System-wide Operating Reserve Requirements

- Various changes to the operating reserve requirements that have occurred or will occur during 2013
  - System real-time reserves to account for historical non-performance (implemented July 2012)
    - Total 10-minute Reserve = 1^{st} Contingency / (100%-20%)
    - TMNSR = 50% x Total 10-minute Reserve
    - TMSR = 50% x Total 10-minute Reserve
    - TMOR = 50% x 2^{nd} Contingency
  - Increase TMNSR in the Forward Reserve Market to account for (a) any historical under-performance of Resources dispatched in response to a system contingency, and (b) the likelihood that more than one half of the forecasted first contingency supply loss will be satisfied using TMNSR (implemented June 1, 2013)
    - TMNSR = 1^{st} Contingency / (100%-20%)
      x bias of the historical delivery ratio of TMNSR to TMSR
  - System-wide replacement reserve (to be implemented winter 2013/2014)
    - 180 MW during winter period
    - 160 MW during summer period

LFRM Overview

- LFRM requirements reflect the amount of 30-minute reserves required to meet the ***local 2nd contingency under normal operating conditions***
  - Accounts for reserves imported across the interfaces into constrained locations (External Reserve Support or ERS)
- Depending on system conditions -- the configuration of the interface, the largest generator on-line, loads, and the total resources on-line in the area -- the local 2nd contingency will be either a line or a generator(s)
- The requirements for the LFRM are currently derived from an analysis of historical data
  - A rolling, two-year historical data of daily peak hour operational requirements for each Reserve Zone for like periods (summer or winter)
  - The requirements are modified, as required, to reflect changes in the configuration of the transmission system or addition/retirement of major generating resources

Calculation of LFRM Requirement

- For the peak hour of each weekday and for each Reserve Zone, the daily Locational Reserve Requirement (dLRR) is first calculated
  - dLRR is the amount of 30-minute contingency response, given the available transfer capability on the interface, that must be physically located within the import-constrained area to ensure recovery from the loss of the 2nd contingency
  - A calculated value based on several data elements of the system
- These daily peak hour operating requirements are aggregated into a frequency distribution. The MW value of the 95^{th} percentile of the distribution establishes the LFRM requirement for each Reserve Zone

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DEVELOPMENT OF REPRESENTATIVE FUTURE LFRM REQUIREMENT

Scopes

- Reserve Zones
  - SWCT
  - Connecticut (also referred to as Greater Connecticut)
  - NEMA/Boston
- Study Period
  - 2014 - 2017 (both summer and winter seasons)
- Major Study Assumptions
  - Latest historical data for generation and transmission performance used for developing most recent seasonal LFRM requirements
  - 2013 CELT report used for future loads, generation and demand resource additions and retirements
  - Transmission limits consistent with RSP13

Uncertainty of Future Reserve Requirements

- Factors that would impact 2nd contingency
  - System condition/topology changes that result in interface limit changes, e.g.
    - New lines in-service
    - Outages (generator and line contingency, maintenance, etc.)
  - Largest generation contingency changes, e.g.
    - Uprate
    - Retirement/deactivation
- Factors affecting the external reserve support
  - Load level
    - Demand resource impact
  - Generation dispatch pattern
    - Addition/retirement of base-load unit

Future Reserve Requirement Projection through Simulation

- Future reserve requirement for each Reserve Zone can be evaluated through probabilistic simulations that generate a series of possible system conditions for future periods
  - Historical system conditions are used to develop the probability distribution for each input variable and their correlations for the simulation
    - Daily peak load
    - Local generation online
    - Largest generation contingency
    - Interface limits ($Limit_{N-1}$, $Limit_{N-2, Gen}$, and $Limit_{N-2, Line}$)
  - Adjustments are made to these historical distributions to better reflect future system conditions, e.g.
    - Load scaled up/down to forecast values
    - Interface limits changed based on projected system topology
    - Local generation adjusted for addition/retirement of units and the impacts of DR
- Some operational constraints and interdependency may not be adequately captured in the simulation of the future system

Simulation Assumptions and Scenarios

- 2nd Generation Contingency

Reserve Zone	Assumed 2nd generation contingency	Modeling
SWCT	Loss of Milford 1 & 2	520 MW
CT	Loss of Millstone Unit 3	1,230 MW
NEMA/BOSTON	Loss of Mystic 8 and 9	1) assumed at 1,400 MW 2) assumed as a random variable to follow its historical distribution

Simulation Assumptions and Scenarios
- Transmission Import Capability for 2013-2017

Reserve Zone	Assumed Import Capability
SWCT	1) $Limit_{N-1} = Limit_{N-2,Gen}$ = 3,200 MW; $Limit_{N-2,Line}$ = 2,300 MW 2) N-1, N-2 limits assumed as random variables to follow their historical distributions
CT	1) $Limit_{N-1} = Limit_{N-2,Gen}$ = 3,050 MW (2013-2016 GSRP) = 2,800 MW (2017 IRP of NEEWS) $Limit_{N-2,Line}$ = 1,850 MW (2013-2016 GSRP) = 1,600 MW (2017 IRP of NEEWS) 2) N-1, N-2 limits assumed as random variables to follow their historical distributions
NEMA/BOSTON	1) $Limit_{N-1} = Limit_{N-2,Gen}$ = 4,900 MW = 4,850 MW (2014*) $Limit_{N-2,Line}$ = 3,700 MW = 4,175 MW (2014*) * changes to reflect Salem Harbor units' retirement, and North Shore Upgrade 2) N-1, N-2 limits assumed as random variables to follow their historical distributions

Simulation Assumptions and Scenarios

- Load and Passive DR (MW)

Reserve Zone	Year	50/50 Forecast		90/10 Forecast		Passive DR	
		Summer	Winter	Summer	Winter	Summer	Winter
SWCT	2013	3,655	2,870	3,990	2,925	191	190
	2014	3,710	2,885	4,040	2,940	188	188
	2015	3,770	2,895	4,110	2,955	185	185
	2016	3,830	2,910	4,175	2,970	153	152
CT	2013	7,210	5,670	7,865	5,780	376	375
	2014	7,310	5,695	7,965	5,805	371	371
	2015	7,435	5,715	8,105	5,835	365	365
	2016	7,555	5,745	8,230	5,860	302	301
NEMA/BOSTON	2013	5,835	4,600	6,300	4,695	206	203
	2014	5,930	4,645	6,400	4,740	285	284
	2015	6,050	4,695	6,525	4,785	333	332
	2016	6,165	4,735	6,645	4,830	357	356

Simulation Assumptions and Scenarios

- Others

- 30ACT (Non-generation based 30 minute actions)
  - SWCT and CT: 10% (not to exceed 500 MW) of post 2^{nd} contingency native area load shed for line-line condition
  - NEMA/BOSTON: 400 MW of post 2^{nd} contingency native area load shed for line-line condition

- Adjustments to historical local online generation
  - CT historical local online generation data were adjusted based on the average output of Kleen since its in-service date
  - NEMA/BOSTON historical local online generation data were adjusted to reflect the impacts of generation additions and retirements
    - Salem Harbor unit 1 – 2 retired in 2012
    - Salem Harbor unit 3 – 4 retirement in 2014
    - Footprint (674 MW) in-service in 2016

Software Used for Simulation

- Crystal Ball (Professional Edition)
  - Crystal Ball is an Excel based risk analysis, simulation and optimization software marketed by Decisioneering (a division of Oracle/Hyperion)
    - An add-in module to Microsoft Excel to provide an easy way to perform forecast simulations
    - Uses Monte Carlo simulation to generate a wide range of possible optimized outcomes in terms of the range of forecast outputs and their probabilities based on the input assumptions
  - http://www.oracle.com/crystalball/index.html

APPENDIX

Calculation Formula of LFRM

(a) The Second Contingency in each Reserve Zone is calculate d as

2^{nd} Gen = $Limit_{N-1} - Limit_{N-2,\ Gen}$ + CONTG – 30ACT

2^{nd} Line = $Limit_{N-1} - Limit_{N-2,\ Line}$ – 30ACT

(b) The External Reserve Support (ERS) is calculated as follows

ERS = $Limit_{N-1}$ – (Load – Gen)

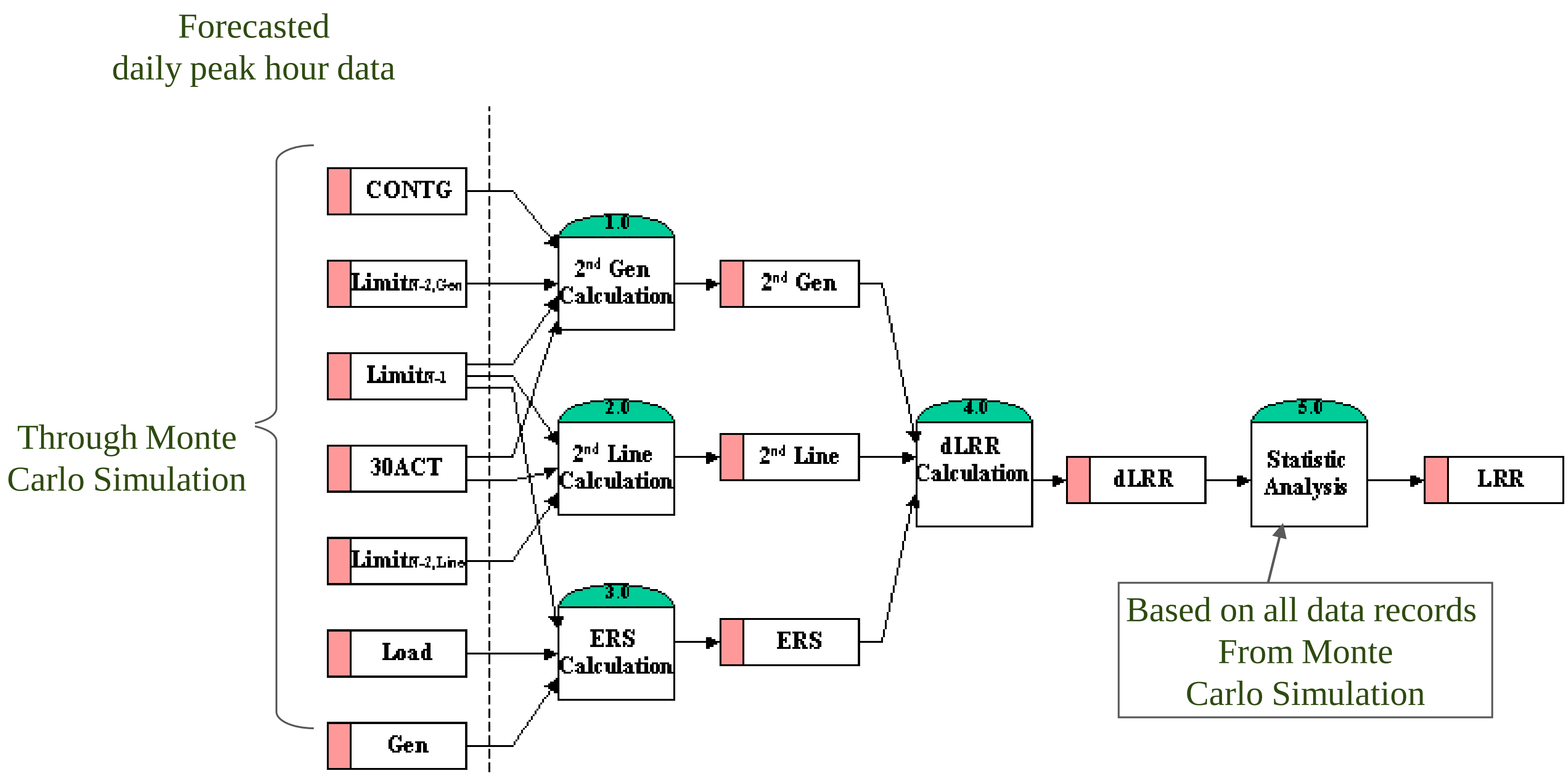
(c) The daily Locational Reserve Requirement (dLRR) equals

dLRR = MAX(2^{nd} Gen, 2^{nd} Line) – ERS

Where,

- LOAD = Forecast daily peak load;
- GEN = Minimum capacity commitments required for 1^{st} contingency coverage from day ahead;
- CONTG = Second generation contingency;
- $Limit_{N-1}$ = First contingency interface limit;
- $Limit_{N-2,\ Gen}$ = Second generation contingency interface limit;
- $Limit_{N-2,\ Line}$ = Second line contingency interface limit;
- 30ACT = Non-generation based 30 minute actions, e.g., certain OP4 actions, load swap, Transmission Owner authorized load shedding

Locational Reserve Requirements Forecast Data Flow Diagram



Note:

Process 1.0 : 2^{nd} Gen = $Limit_{N-1}$ - $Limit_{N-2,Gen}$ + CONTG - 30ACT

Process 2.0: 2^{nd} Line = $Limit_{N-1}$ - $Limit_{N-2,Line}$ –30ACT

Process 3.0: ERS = $Limit_{N-1}$ –(Load – Gen)

Process 4.0: dLRR = Max(2^{nd} Gen, 2^{nd} Line) – ERS

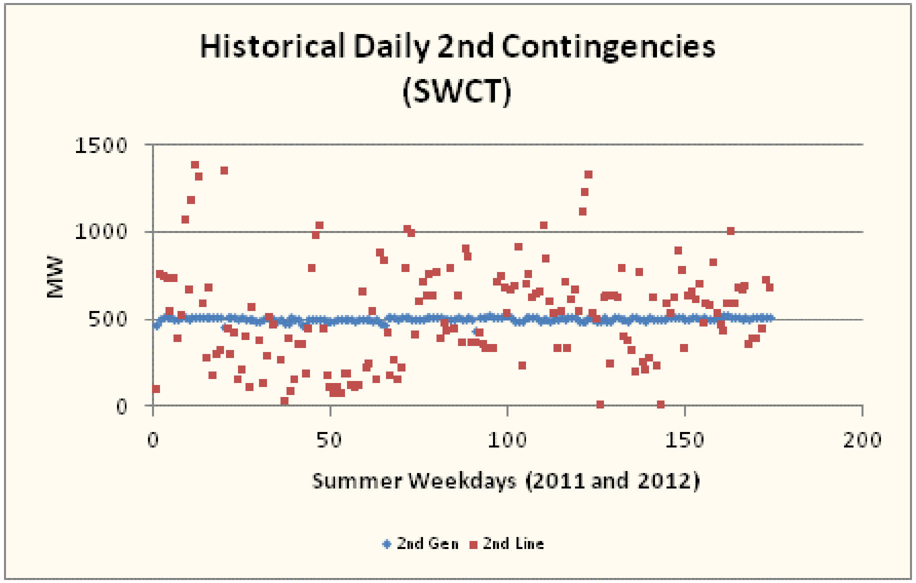
Process 5.0: set LRR to be 95^{th} percentile rank level

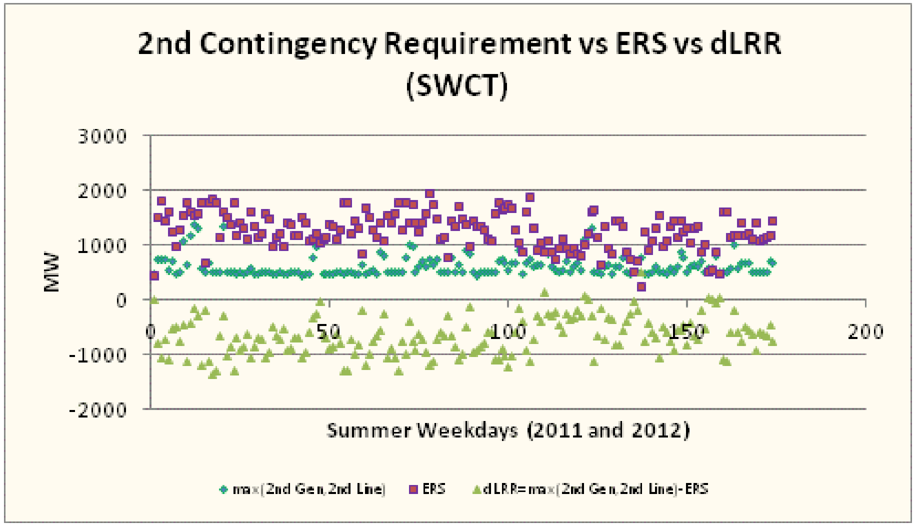
Simulation Procedure to Generate dLRR data

- After input variables randomly sampled
  - Process 1.0
    - 2nd Gen = $\text{Limit}_{N\text{-}1}$ - $\text{Limit}_{N\text{-}2,Gen}$ + CONTG – 30ACT
  - Process 2.0
    - 2nd Line = $\text{Limit}_{N\text{-}1}$ - $\text{Limit}_{N\text{-}2,Line}$ – 30ACT
  - Process 3.0
    - ERS = $\text{Limit}_{N\text{-}1}$ – (Load – Gen)
  - Process 4.0
    - dLRR = Max(2nd Gen, 2nd Line) – ERS
- After completion of simulation (thousands of iterations)
  - Process 5.0
    - Form frequency distribution of dLRR, and set LRR to 95th percentile of the distribution

Historical Summer Data SWCT

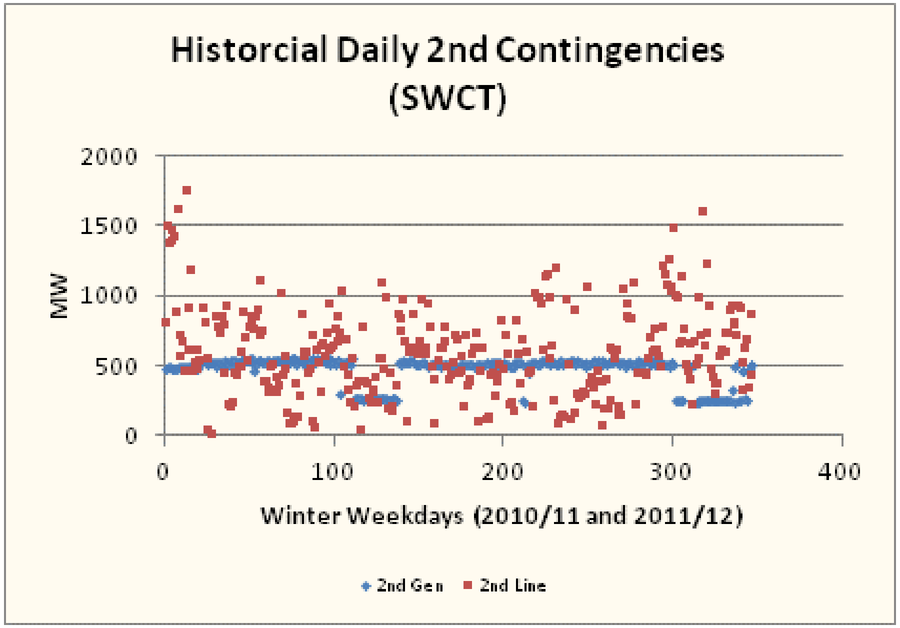
- 2^{nd} contingency was a line or a generator with almost equal frequency
- 2^{nd} Gen was relatively constant
- 2^{nd} Line was volatile, and the magnitude can be much higher than 2^{nd} Gen
- No reserve requirement for the zone for most of the time as adequate external reserve support was available

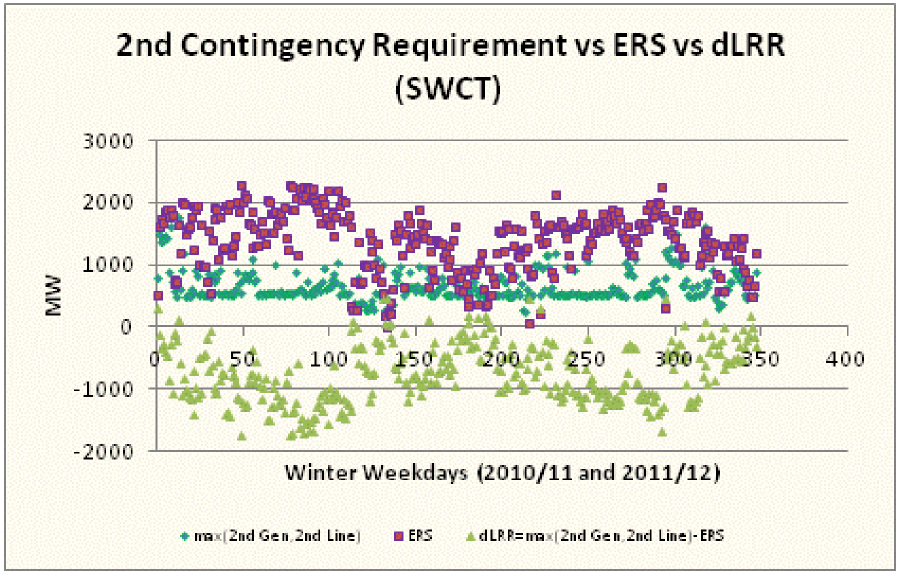




Historical Winter Data SWCT

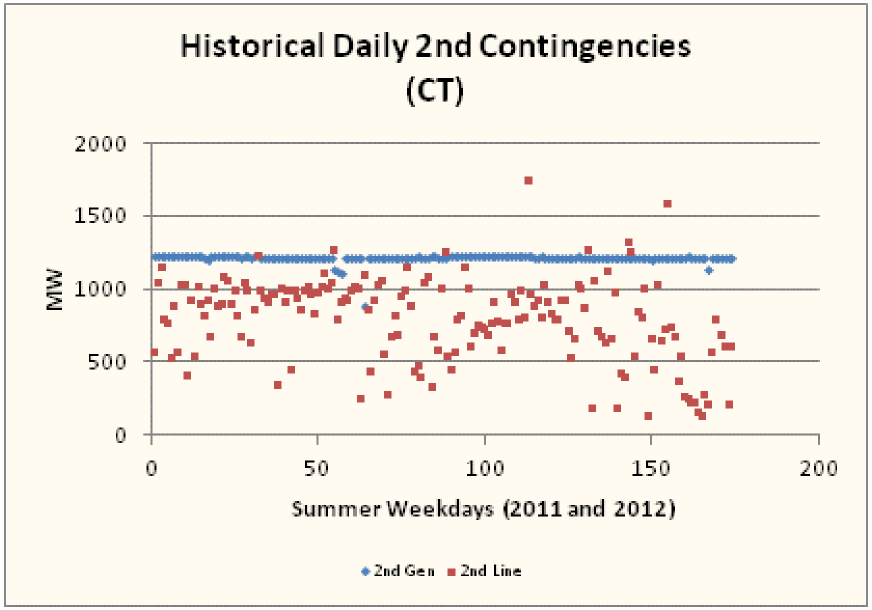
- 2^{nd} contingency was a generator(s) for about 40% of the time, and was a line for about 60%
- 2^{nd} Gen was relatively constant
- 2^{nd} Line was volatile, and the magnitude can be much higher than 2^{nd} Gen
- No reserve requirement for the zone for most of time as adequate external reserve support was available



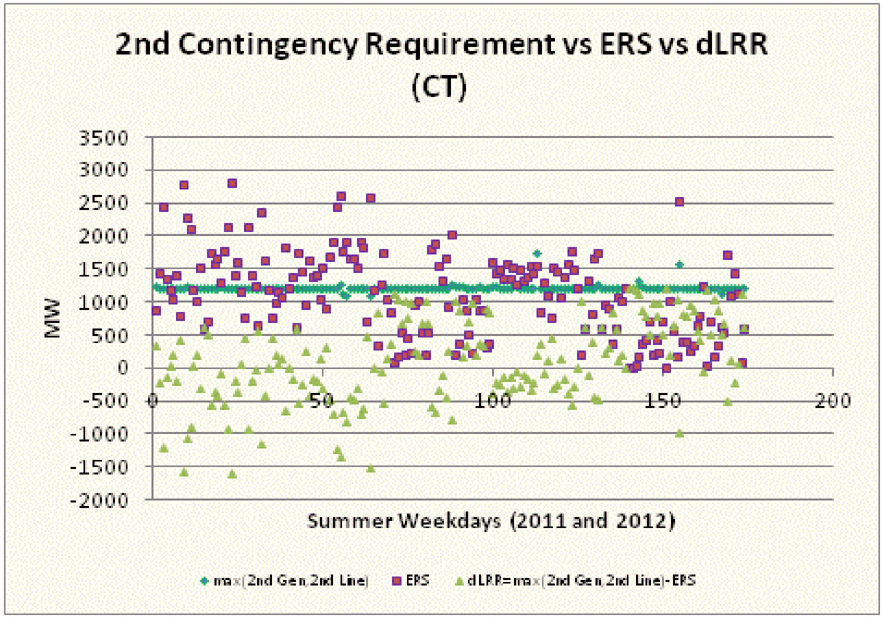


Historical Summer Data CT

- 2nd contingency was mostly a generator, and relatively constant

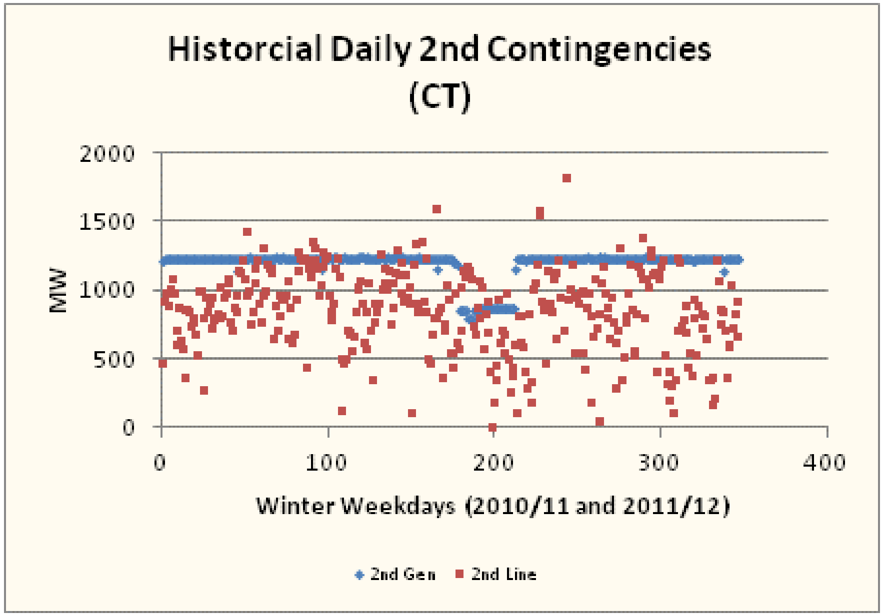


- Certain amount of zonal reserve was required for ~50% of time of last two summers

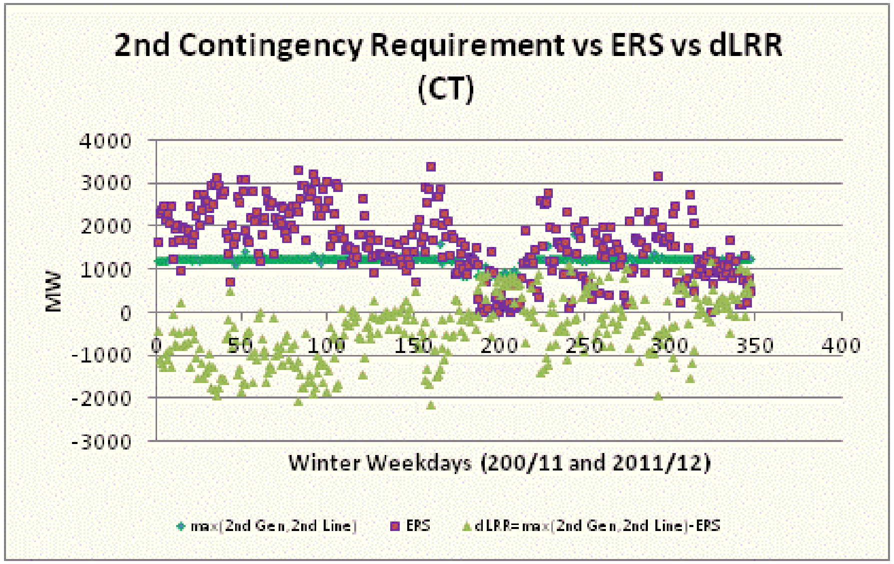


Historical Winter Data CT

- 2^{nd} contingency was mostly a generator, and relatively constant

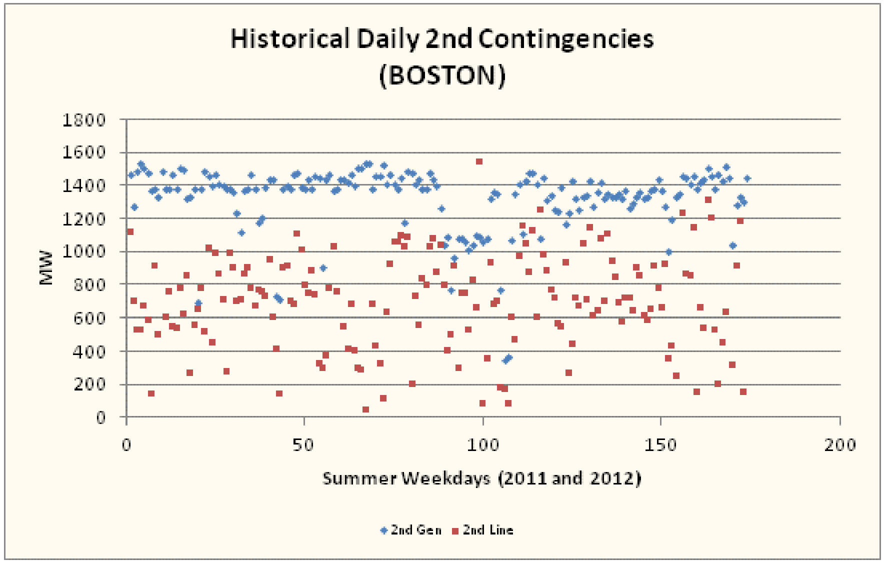


- Certain amount of zonal reserve was required for ~30% of time of last two winters

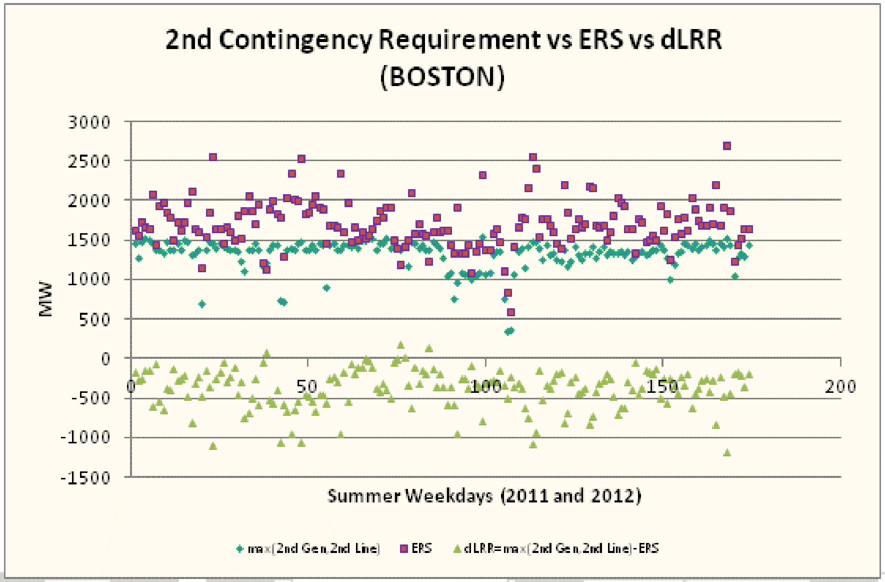


Historical Summer Data NEMA/BOSTON

- 2^{nd} contingency was mostly a generator(s), and relatively constant

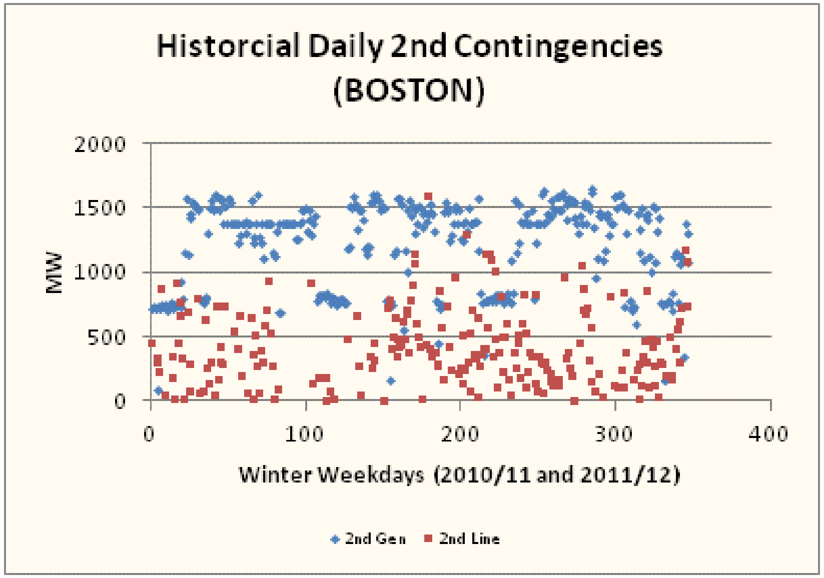


- No reserve requirement for the zone for most of the time as adequate external reserve support was available



Historical Winter Data NEMA/BOSTON

- 2nd contingency was mostly a generator
- Both 2nd Gen and 2nd Line contingency was relatively volatile



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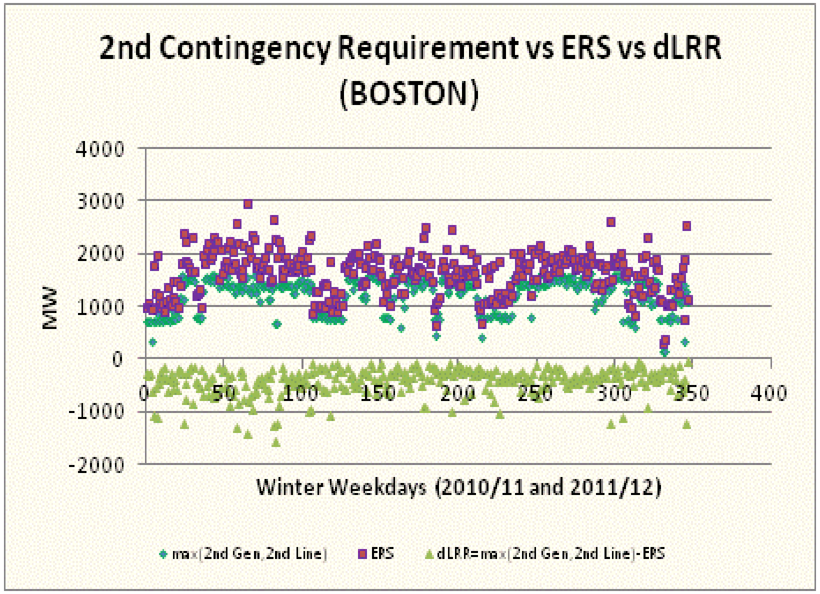

Questions