NEW ENGLAND 2011 COMPREHENSIVE REVIEW OF Resource Adequacy

ISO New England Inc.

Final Report – Approved by RCC on November 29, 2011

1.0 EXECUTIVE SUMMARY

ISO New England Inc. (ISO-NE) is the not-for-profit corporation responsible for the reliable operation of New England's bulk power generation and transmission system. It also administers the region's wholesale electricity markets and manages the comprehensive planning of the regional bulk power system. As part of its planning functions, ISO-NE is the Planning Coordinator for the New England Area of the Northeast Power Coordinating Council (NPCC). One of the ISO-NE Planning Coordinator's responsibilities is to conduct studies and provide results to demonstrate that the New England Area bulk power system complies with the NPCC *Basic Criteria for Design and Operation of Bulk Power Systems* (NPCC Regional Reliability Reference Directory #1)[1] to satisfy NPCC planning compliance requirements.

This 2011 New England Comprehensive Review of Resource Adequacy, covering 2012 through 2016, was prepared by ISO-NE to satisfy NPCC compliance requirements. This comprehensive review follows the guidelines as specified in the Appendix D of NPCC Regional Reliability Reference Directory #1 entitled *Guidelines for Area Review of Resource Adequacy* . This review supersedes the New England 2008 Comprehensive Review of Resource Adequacy[2], which was approved by the Reliability Coordinating Committee (RCC) on November 19, 2008.

1.1. MAJOR FINDING

The findings of this review are based on the results of a resource adequacy assessment of the New England bulk power system using the General Electric Multi Area Reliability Simulation Program (GE MARS) and results of other studies conducted for the ISO New England 2011 Regional System Plan (RSP 11)[3].

The major findings of this comprehensive review are as follows:

- The economic recession has slowed the growth in summer peak demand, while wholesale electricity markets and other factors have stimulated the successful development of supply and demand resources to meet the needs of the New England region. New England will meet the NPCC resource adequacy criterion of disconnecting firm load customers no more than 0.1 days/year for each year of the study period.

- While natural gas remains the dominant fuel within New England's electric power generation sector, the region's diversity and expected reliability of natural gas supply has improved as a result of the new LNG terminals, storage facilities, and new expansion projects on the pipelines designed to improve the ability to deliver natural gas to the region.

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[1] https://www.npcc.org/Standards/Directories/Directory%201%20-%20Design%20and%20Operation%20of%20the%20Bulk%20Power%20System%20Full%20Member%20Approval%20December%2001,%202009%20GJD.pdf

[2] A copy of this review can be found at: https://www.npcc.org/Library/Resource%20Adequacy/NE_2008_Comprehensive_Review_of_Resource_Adequacy%20-%20Approved%20by%20RCC%20on%20Nov192008.pdf

[3] http://www.iso-ne.com/trans/rsp/index.html.

- The proposed Air Toxics Rule will likely go into effect during this review period, and could drive the retirements of ~3,000 MW (mainly oil-fired generation capacity) in New England by 2015. If all of these units would retire, New England would need to add 300 MW of resources for 2015, and 750 MW for 2016 to satisfy the regional reliability needs. These additional required resources may come from the development of new resources, and/or capacity imports.

- Developing wind resources in the ISO Generation Interconnection Queue will likely be a major source for Renewable Portfolio Standards compliance in the New England states. A comprehensive *New England Wind Integration Study* has been completed to identify the operational effects of large-scale wind integration in New England, which will serve as the basis for regional policies and necessary changes to market and reliability rules to facilitate the large-scale integration of wind resources.

- Five major 345 kV transmission projects have been completed since the 2008 review; three additional projects have completed siting and are under construction; and three others have either completed siting, are in siting, or are expected to be in siting by the end of 2011. These projects reinforce critical load pockets, such as in Southwest Connecticut and Boston, and areas that have experienced significant load growth, such as northwest Vermont.

1.2. Summary of Major Assumptions and Results

Table 1 shows the major assumptions used in this review, and Table 2 summarizes the LOLE results. The detailed assumptions are documented in the Appendix section of this review while the results are documented in sections 5.0 *Resource Adequacy Assessment*.

Table 1 Major Assumptions

Assumptions	Description
Reliability Criterion	NPCC Criterion: no more than once in 10 years of firm load disconnection (LOLE of 0.1 days/ year)
Load Model	Hourly loads with forecast uncertainty
Reliability Model	GE MARS
Expected Capacity Resources	Based on the resources procured by ISO New England for the forward capacity market
New Resource Capacity Additions	Include all the planned resources with a capacity supply obligation (CSO) for the forward capacity market
Resource Capacity Retirements/Deactivations	Assume all the existing resources without capacity supply obligation unavailable
Resource Availability	EFORd and Planned Maintenance: 5 year average (June 2006 through May 2011)
Tie Benefits from Neighboring Systems	2012: 1,752 MW 2013: 1,700 MW 2014: 1,689 MW 2015- 2016: 1,676 MW
Emergency Operating Procedures (Load Relief, Voltage Reduction)	Assumed 1.5% of load relief from Voltage Reduction during OP 4 Actions 6 and 8

Internal Transmission Constraints	Modeled. Transmission system representation[4] and the interface limits are shown in Appendix A.1.7 of this report.

Table 2 LOLE Results

Year	Expected Resources (MW)	Reference Load Forecast		High Load Forecast	
		50/50 Peak[5] (MW)	LOLE (days/year)	50/50 Peak (MW)	LOLE (days/year)
2012	32,840	28,095	0.012	28,520	0.021
2013	33,362	28,525	0.012	29,085	0.024
2014	34,395	28,970	0.005	29,645	0.014
2015	32,886	29,380	0.044	30,150	0.083
2016	32,664	29,775	0.067	30,635	0.140

The resources assumed available for the years 2012 to 2014 for the LOLE calculation are the resources that have been procured by ISO New England to meet the New England's Installed Capacity Requirement (ICR) for the respective periods. Since no capacity auctions have been conducted for the years of 2015 and 2016, the New England internal generation and demand resources with capacity supply obligations for 2014 are assumed to be available for these two years. Other resources assumed available for 2015 and 2016 include the grandfathered imports.

[4] The subarea representation is consistent with New England's RSP 11.

[5] The 50/50 peak is the peak load that has 50% chance of being exceeded.

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3.0 INTRODUCTION

As part of its Reliability Assessment Program (RAP), NPCC conducts resource adequacy reviews of its member areas to ascertain whether or not each area will have adequate resources to meet the NPCC Resource Adequacy Design Criterion. The purpose of this report is to document the results of the ISO-NE comprehensive resource adequacy studies, covering 2012 to 2016, for NPCC review. The results are documented in accordance with the reporting guidelines as specified in Appendix D of NPCC Regional Reliability Reference Directory #1, entitled *Guidelines for Area Review of Resource Adequacy* [6]. This study supersedes the New England 2008 Comprehensive Review of Resource Adequacy[7], which was approved by the NPCC Reliability Coordinating Committee on November 19, 2008.

On June 16, 2006, the Federal Energy Regulatory Commission (FERC) approved a Settlement Agreement[8] to create the Forward Capacity Market (FCM) in New England. The FCM is a long-term wholesale market designed to promote adequate and economic investment in supply and demand-side resources. The purpose of the FCM is to procure the required amount of installed capacity resources to maintain system reliability, consistent with the region's criteria for resource adequacy. Approximately three years in advance, the ISO forecasts future electricity demand and determines the quantity of resources needed to meet this demand after accounting for uncertainties, contingencies, and resource performance, and procures these resources through the market. Through the FCM, which consists of a series of auctions and bilateral trading periods, the specific resources committed to meeting the New England ICR and related values are identified. Purchased capacity resources must be available in the specified timeframe to ensure the region has adequate resources to meet regional resource needs.

Since 2008, five forward capacity auctions have been successfully conducted for the commitment periods from 2010/11 to 2014/15, and an adequate amount of resources has been procured to meet New England's capacity needs for these respective periods.

The assumptions for resources, load and transmission used for this review are consistent with New England's 2011Regional System Plan, Forward Capacity Market, and the 2011 Forecast Report of Capacity, Energy, Loads and Transmission (CELT 2011[9]).

3.1. PREVIOUS COMPREHENSIVE REVIEW OF NEW ENGLAND'S RESOURCE ADEQUACY

The RCC approved the previous New England Comprehensive Review of Resource Adequacy in November 2008. The findings of that review showed that New England would meet the NPCC Resource Adequacy Design Criterion for the period studied under the expected load and resource conditions.

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[6] https://www.npcc.org/Standards/Directories/Directory%201%20-%20Design%20and%20Operation%20of%20the%20Bulk%20Power%20System%20Full%20Member%20Approval%20December%2001,%202009%20GJD.pdf

[7] A copy of this review can be found at: https://www.npcc.org/Library/Resource%20Adequacy/NE_2008_Comprehensive_Review_of_Resource_Adequacy%20-%20Approved%20by%20RCC%20on%20Nov192008.pdf

[8] http://www.iso-ne.com/regulatory/ferc/filings/2006/mar/er03-563-000_030_055_3-7-06_corrected.pdf

[9] http://www.iso-ne.com/trans/celt/report/2011/2011_celt_rprt.pdf

3.2. Comparison of Current and Previous Reviews

3.2.1. Load Forecast

Table 3 tabulates the annual (summer) peak load forecasts used in the 2008 and 2011 reviews. Figure 1 shows these values in graphical form.

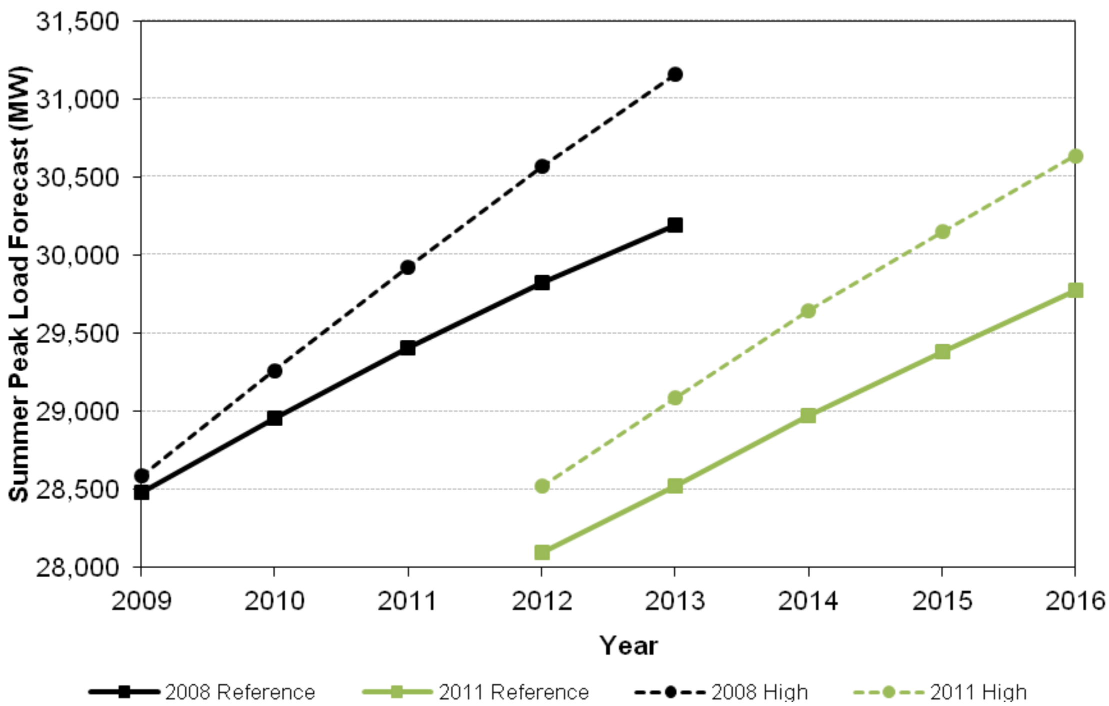
The annual (summer) peaks are presented for both the reference load forecast and high load forecast scenarios. The reference load forecast and the high load forecast are developed based on a "most likely" long-run economic and demographic forecast and a high growth long-run economic and demographic forecast respectively, from Moody's Economy.com.

The peak loads shown in Table 3 have a 50% chance of being exceeded (50/50 peaks) and are expected to occur at a weighted New England-wide, average temperature of 90.2 ºF. While Table 3 shows the annual 50/50 peaks of the forecast, the inherent uncertainty of the forecast from weather variations is modeled within the LOLE calculation. The 50/50 peaks are tabulated in Table 3 for ease of reference and to facilitate comparisons.

Table 3 Comparison of Annual Peak Load Forecasts

	Annual Peak (MW)			
	Reference Load Forecast		High Load Forecast	
Period	2008 Review	2011 Review	2008 Review	2011 Review
2012	29,820	28,095	30,565	28,520
2013	30,190	28,525	31,155	29,085
2014	N/A	28,970	N/A	29,645
2015	N/A	29,380	N/A	30,150
2016	N/A	29,775	N/A	30,635

Figure 1 Comparison of Summer Peak Load Forecasts



As shown in Table 3, both the 2011 reference and high load forecasts are lower than those used for the 2008 review. The New England and national economic recession that started in mid-2008 dominates the changes in the annual and seasonal peak demand forecasts. The new load forecasts are based on economic forecasts from October 2010 that show the low point of the recent recession occurring 2009, with the recovery beginning in 2010. The projected Compound Annual Growth Rate (CAGR) of the 2008 forecast is approximately 1.01%. The 2011 forecast projects a CAGR of 1.4%.

3.2.2. Resources

Since the 2008 review, capacity auctions have been successfully concluded for the years from 2010 to 2014, and ISO New England has procured an adequate amount of resources to meet the projected installed capacity requirements for these years. The specific resources committed to meeting the New England regional and zonal requirements have been identified, and are used for this assessment. Since the capacity auctions for the years of 2015 and 2016 have not been held, the resources committed for 2014 are used for these two years, with the exception of the capacity imports that have no supply obligations for these years.

Table 4 and Figure 2 compare the MW values of resources assumed for the 2008 and 2011 reviews.

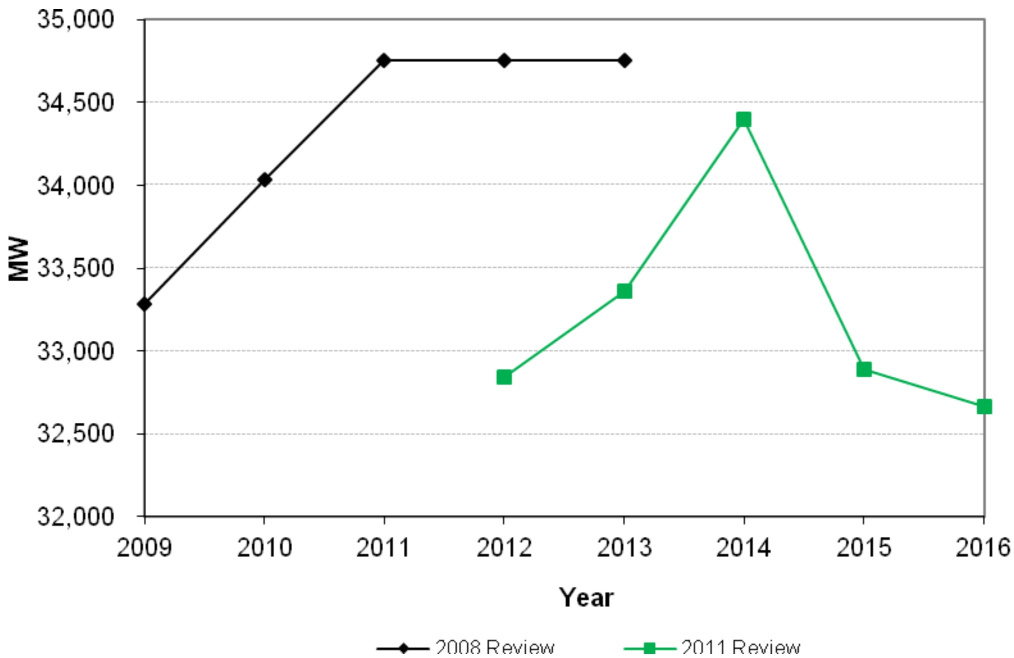
The NPCC Resource Adequacy Design Criterion allows the use of load and capacity relief from the implementation of emergency operating procedures to meet system capacity needs. Specifically, the tie benefits assumed available from the interconnections and load relief from implementing voltage reductions are used in meeting the 0.1 days/year LOLE but are not reflected in Table 4 and Figure 2. In the 2008 review, tie benefits were assumed to be 1,800 MW and load relief from implementing a 5% voltage reduction was assumed to be a 1.5% reduction from the peak loads. In the 2011 review, the tie benefit assumptions is about 1,700 MW and load relief from implementing a 5% voltage reduction is assumed to result in a 1.5% reduction in the peak loads. The 2011 review assumptions are based on recent study results.

Table 4 Comparison of 2008 vs. 2011 Resources Assumptions (MW)[10]

Period	Resource Category	2008 Review	2011 Review
2012	Generating Resources	31,467	28,702
	Demand Resources	2,384	2,607
	Net Purchase and Sale	905	1,531
	Total	**34,756**	**32,840**
2013	Generating Resources	31,467	28,712
	Demand Resources	2,384	3,004
	Net Purchase and Sale	905	1,646
	Total	**34,756**	**33,362**
2014	Generating Resources	N/A	29,245
	Demand Resources	N/A	3,399
	Net Purchase and Sale	N/A	1,751
	Total	**N/A**	**34,395**
2015	Generating Resources	N/A	29,245
	Demand Resources	N/A	3,399
	Net Purchase and Sale	N/A	242
	Total	**N/A**	**32,886**
2016	Generating Resources	N/A	29,245
	Demand Resources	N/A	3,399
	Net Purchase and Sale	N/A	20
	Total	**N/A**	**32,664**

[10] Demand resource values include 8% transmission and distribution loss gross-up.

Figure 2 Comparison of 2008 vs. 2011 Resource Assumptions



4.0 Resource Adequacy Criterion

4.1. Statement of New England Resource Adequacy Criterion

The New England Resource Adequacy Criterion[11] complies with the NPCC Resource Adequacy Design Criterion and reads:

"Resources will be planned and installed in such a manner that, after due allowance for the factors enumerated below, the probability of disconnecting noninterruptible customers due to resource deficiency, on the average, will be no more than once in ten years. Compliance with this criteria shall be evaluated probabilistically, such that the loss of load expectation [LOLE] of disconnecting noninterruptible customers due to resource deficiencies shall be, on average, no more than 0.1 day per year.

a. *The possibility that load forecasts may be exceeded as a result of weather variations.*

b. *Immature and mature equivalent forced outage rates appropriate for generating units of various sizes and types, recognizing partial and full outages.*

c. *Due allowance for scheduled outages and deratings.*

d. *Seasonal adjustment of resource capability.*

e. *Proper maintenance requirements.*

f. *Available operating procedures.*

g. *The reliability benefits of interconnections with systems that are not Governance Participants.*

h. *Such other factors as may from time-to-time be appropriate."*

4.2. Application of New England Resource Adequacy Criterion

The New England Resource Adequacy Criterion is used to determine the amount of resources needed to reliably satisfy system demand. In calculating the amount of resources needed, New England also takes into account the tie benefits that are assumed available from the neighboring systems. The Québec, New York and New Brunswick interconnections have been modeled within this reliability review.

To properly capture the intended operation of the system, the emergency operating procedures that are implemented during periods of capacity deficiencies are also modeled in the form of the amount of load relief that is assumed obtainable. It is assumed that the system operators will always maintain at least some minimum level of operating reserve to ensure control over transmission loadings and maintain a minimum reliability level.

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[11] http://www.iso-ne.com/rules_proceds/isone_plan/index.html.

Table 5 documents the actions of ISO New England Operating Procedure No 4 (OP 4) – *Action During A Capacity Deficiency*[12]. In actual practice, these actions may be implemented in a different order to reflect the situation and the magnitude of the expected deficiency experienced at the time. Actions 1, 2, 5, 6 and 8 were modeled in this review. OP 4 Actions 3, 4, 7, 9, 10 and11were not modeled as load relief in this reliability assessment and are therefore listed as contingency resources. The amount of capacity assistance obtainable through OP 4 Action 5 is modeled as tie reliability benefits and the assumed benefits are shown in Appendix A.1.3.

4.3. Statement of Required Resources

New England does not have a required reserve margin criterion. Required resources are planned based on meeting the NPCC LOLE reliability criterion of no more than one day in ten years disconnection of non-interruptible customers.

Interconnection benefits from the neighboring systems of New York, Hydro Quebec, and Maritimes are modeled in this review. The value of such benefits in terms of MWs is tabulated in Table 13 of Appendix A.1.3

4.4. Comparison of New England and NPCC Resource Reliability Criterion

New England's Resource Adequacy Criterion as defined in Section 4.1 complies with the Resource Adequacy Criterion established by the NPCC.

4.5. Resource Adequacy Studies Conducted Since the 2008 Comprehensive Review

Each year, ISO New England prepares a comprehensive 10-year Regional System Plan to evaluate the system needs, solutions and process required to ensure the reliable performance of the New England bulk power system. The 2011 plan presents the results and findings of the recent analysis on loads, resources, and transmission of the New England bulk power system through 2020.

[12] OP 4 is activated whenever the system is short of resources to meet expected load plus operating reserve requirement. For details of OP 4, please visit: http://www.iso-ne.com/rules_proceds/operating/isone/op4/op4_rto_final.pdf

Table 5 Estimate of Additional Generation and Load Relief from System Wide Implementation of Actions in ISO New England Operating Procedure NO. 4 - Action During a Capacity Deficiency Based on a 26,618 MW System Load [13]

Action #	Description	MW
1	Implement Power Caution and advise Resources with a Capacity Supply Obligation to prepare to provide all associated capacity. Notify "Settlement Only" generators with capacity supply obligations to monitor the status of reserve pricing to meet those obligations. Begin to allow the depletion of 30-minute reserve.	0 0[14] About 600 MW[15]
2	Dispatch Real-Time Demand Resources in the amount and location required.	550 [16]
3	Voluntary Load Curtailment of Market Participants' Facilities	40
4	Implement Power Watch	0
5	Schedule Market Participant-submitted EETs Arrange to purchase Control Area-to-Control Area emergency	Variable (could be between 0 and 1,000 MW)
6	Implementation of 5% VR Requiring More Than 10 Minutes Dispatch Real-Time Emergency Generation Resources in the amount and location required. Alert NYISO that sharing of reserves within NPCC may be required	130 [17] 375 [26]
7	Request Generating Resources not subject to a Capacity Supply Obligation to voluntarily provide energy for reliability purposes.	Variable (could be between 0 and 1,500 MW)
8	Implementation of 5% VR Requiring 10 Minutes or Less	270 [27]
9	Transmission Customer Generation Not Contractually Available to Market Participants During a Capacity Deficiency Voluntary Load Curtailment by Large Industrial and Commercial Customers	5 200[24]
10	Radio and TV Appeals for Voluntary Load Curtailment Implement Power Warning	200
11	Request State Governors to Reinforce Power Warning Appeals	100
Grand Total		2470-4970

[13] MW values are shown in this table for illustration purposes. These will change according to system conditions and market rule modifications.
[14] Based on Summer Ratings. Assumes 25% of total MWs of Settlement Only units <5 MW will be available and respond.
[15] The actual load relief obtained is highly dependent on circumstances surrounding the appeals, including timing and the amount of advanced notice that can be given.
[16] The MW values are reviewed on a quarterly basis; actual available MW amounts can be viewed using the demand response dispatch software.
[17] The MW values are based on a 26,618 MW system load and the most recent voltage reduction test % achieved.

5.0 Resource Adequacy Assessment

5.1. Based On Reference Load Forecast

Table 6 summarizes the LOLE results for the reference load forecast scenario and the resource assumptions detailed in Section 3.2. As shown, New England will meet the NPCC Resource Adequacy Design Criterion of disconnecting firm load customers no more than 0.1 days/year during the study period.

Table 6 LOLE Results Based on Reference Load Forecast

Year	Resources Assumed (MW)	Reference Peak Load Forecast (MW)	LOLE (days/year)
2012	32,840	28,095	0.012
2013	33,362	28,525	0.012
2014	34,395	28,970	0.005
2015	32,886	29,380	0.044
2016	32,664	29,775	0.067

5.2. Based On High Load Forecast

ISO-NE also has analyzed the system resource adequacy under a higher than expected load forecast, which would primarily occur due to higher economic growth. Table 7 shows the LOLE results based on the high load forecast, while using the same resource assumptions as for the reference load forecasts.

Table 7 LOLE Results Based on High Load Forecast

Year	Resources Assumed (MW)	High Load Peak Forecast (MW)	LOLE (days/year)
2012	32,840	28,520	0.021
2013	33,362	29,085	0.024
2014	34,395	29,645	0.014
2015	32,886	30,150	0.083
2016	32,664	30,635	0.140

The results of the high load forecast show that New England would meet the NPCC Resource Adequacy Design criterion through 2015 but would need approximate 400 MW of additional resources to meet that criterion in 2016. There are over 2,000 MW of potential excess from existing resources in New England, that can be used to meet this need should the high load forecast materialize.

5.3. Mechanisms to Mitigate Potential Reliability Impacts of Uncertainty

Under the FCM, the Installed Capacity Requirement is forecasted and purchased three years ahead of the commitment period, based on ISO New England's assumed system conditions three years into the future. The FCM design recognizes that system conditions can change and uncertainties exist in load forecasts, resource ratings and availability, as well as transmission topology. The FCM construct provides measures to mitigate the reliability impacts that might be caused by these potential uncertainties through a series of annual “reconfiguration auctions” conducted prior to each commitment period. These annual reconfiguration auctions will be held in each subsequent year after the FCA for each commitment period. For each such subsequent reconfiguration auction, the ISO will recalculate the Installed Capacity Requirement using the updated forecast of loads and resources. If the recalculated capacity needs are higher than the latest amount of resources purchased for the designated period, ISO New England will purchase additional resources to meet the revised needs in the reconfiguration auctions.

6.0 Planned Resource Capacity Mix

Figure 3 New England's 2011 summer generation capacity mix by primary fuel type (MW and %)

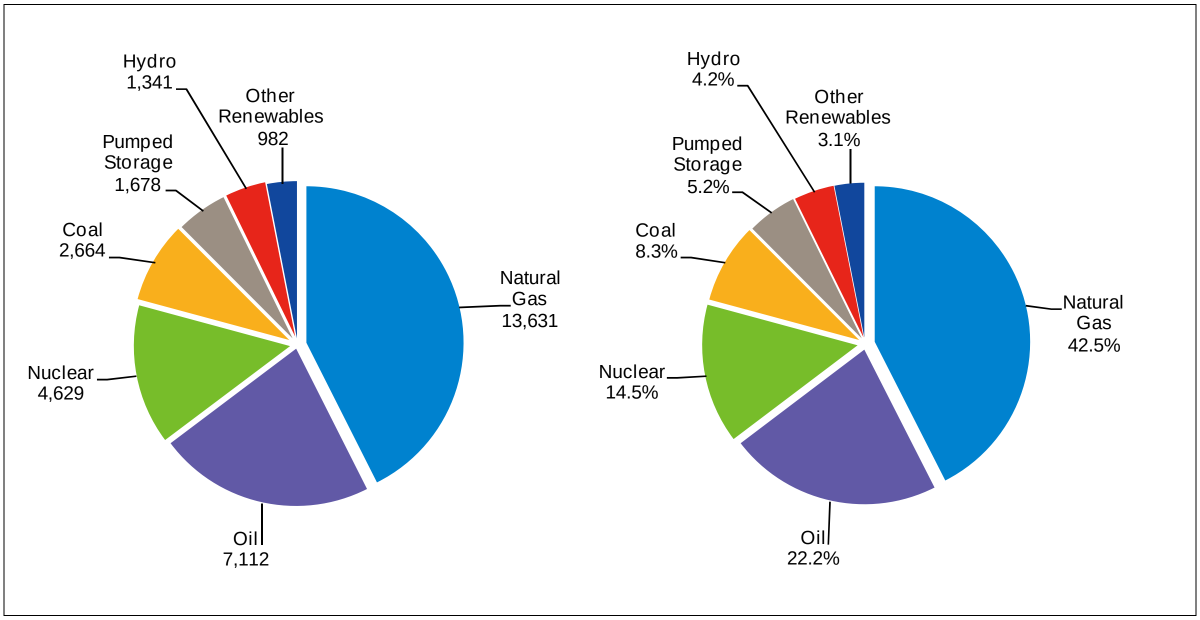

Figure 3 depicts New England's generation capacity mix by primary fuel type[18]. This is expressed in terms of summer capacity ratings (MW and associated percentages) for 2011, based on the 2011 CELT report data. Fossil-based generation continues to comprise almost 73% of the installed capacity within the region, with natural-gas-fired generation (13,631) representing the largest amount of that fossil total, at 42.5% of total generation capacity. Oil-fired generation is the second largest component at 7,112 MW, or approximately 22.2%. Nuclear generation accounts for 4,629 MW, or approximately 14.5%. Coal-fired generation accounts for 2,664 MW, or approximately 8.3%. Conventional hydro (1,341 MW) comprises approximately 4.2%. Pumped-storage (1,678 MW) makes up over 5.2% of the total installed generation capacity. Other renewable resources, including landfill gas (LFG), other biomass gas, refuse (municipal solid waste), wood and wood-waste solids, wind, and tire-derived fuels, total approximately 982 MW and represent about 3.1% of the total installed generating capacity.

6.1. Discussion of Reliability Impacts from Fuel Supply and Transportation

As shown above, the New England region already is heavily reliant on natural gas-fired generation. Additionally, almost 41% of the capacity represented in the ISO's Generation Interconnection Queue is natural-gas-fired generation, and the queue has only small amounts of hydroelectric, coal, and nuclear capacity. This reliance is expected to increase with the potential retirement of aging oil- and coal-fired and nuclear resources.

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[18] Demand resources are not reflected in the mix.

While natural gas as the dominant fuel within New England's electric power generation sector raise concerns, the region's diversity and expected reliability of natural gas supply has improved. This is the result of the new LNG terminals at Northeast Gateway Deepwater Port, the Canaport import and storage facility, and Neptune Deepwater Port. In addition, new expansion projects on the Iroquois and Tennessee pipelines have been designed to improve the ability to deliver natural gas from the Marcellus Shale basin to the region.

Contingencies on the regional gas supply and transmission system could temporarily limit gas deliveries to generators anytime of the year. Effective communication between gas and electric industry operations helps mitigate these and other reliability concerns.

Aging coal- and oil-fired generators are facing additional economic pressures from environmental initiatives. The possibility of these units being replaced or repowered with natural gas will increase the region's dependency on natural gas-fired generation. Other environmental initiatives are promoting the development of renewable resources and energy efficiency. While the addition of variable-output generation resources would reduce the region's dependency on natural gas-fired energy, it also would require natural gas generators to provide additional ramping and frequency regulation, which could affect the operation of the regional natural gas system.

ISO New England has started to address future risks to the regional fuel supply through its Strategic Planning Initiative.

6.2. Discussion of Potential Reliability Impacts Due to Environmental Regulations

Federal, regional, and state environmental regulations have always had an impact on New England generators' operations and costs, and the generators have to continually adjust their compliance plans and permits as these regulations evolve. The US EPA is finalizing a suite of environmental regulations under the *Clean Air Act*, the *Clean Water Act* (CWA), and the *Resource Conservation and Recovery Act* (RCRA). When final, these regulations will affect installed capacity across New England in some manner. Some generators will require significant capital investment for retrofitting facilities with post-combustion control devices, closed-cycle cooling systems, or fuel-switching equipment. Other generators facing these compliance costs may decide to retire.

Among these proposed regulations, the proposed Air Toxics Rule will likely go into effect during this review period. Its final rule is expected by December 2011, and it can become effective as early as in 2012 with full compliance due within 3 years by 2015. In New England, about 7,900 MW of existing generation capacity, either coal steam or oil/gas steam generators, are subject to this proposed Air Toxics Rule. Many coal-fired generators in New England are already equipped with, or are planning additions of, necessary pollution control technologies, and are therefore expected to be in compliance. However, most oil-fired generators lack the necessary pollution control devices, thus requiring additional upgrades and additional downstream controls, or relying on other options like repowering, fuel switching, or fuel blending to comply. The stricter emission limits, and relatively short compliance schedule, could drive retirements of 3,300 MW in New England, mainly oil-fired generation capacity by 2015. The ISO has conducted an analysis to investigate the impacts of these potential retirements, and found that the existing resources in New England are not adequate to satisfy the reliability needs. If all of these units would retire, New England would need to add 300 MW of resources for 2015, and 750 MW for 2016 to satisfy the regional reliability needs. These additional required resources may come from the development of new capacity resources, and/or capacity imports.

6.3. Discussion of Potential Reliability Impacts From Integration of Renewable and Demand Resources

Five New England states have Renewable Portfolio Standards (RPSs), and Vermont has a goal for increasing total generation from renewable resources. These Renewable Portfolio Standards represent state policy targets that load-serving entities (LSEs) (except for municipally owned utilities) must achieve.[19] These LSEs can meet their states' targets in a variety of ways. Developing renewable resources in the ISO Generation Interconnection Queue will likely be a major source for RPS compliance in the New England states.

From the April 1, 2011 ISO Generation Interconnection Queue, there are 62 renewable resource projects representing a total of 3,914 MW, with wind projects composing the largest share at 86%. Biomass projects account for 11% of the projects, and hydroelectric, landfill gas, and fuel cell projects make up the remaining 2%.

In December 2010, the ISO completed the comprehensive *New England Wind Integration Study* (NEWIS) that highlights the operational effects of large-scale wind integration in New England, including the effects of wind forecasting and large-scale wind power on the rest of the generation fleet.[20] NEWIS captured the unique characteristics of New England's electrical power system and wind resources—including historical load and ramping profiles, geography, topology, supply- and demand-side resource characteristics, and wind profiles—and the unique impacts that these characteristics can have on system operations and planning with increasing wind power penetration.[21] In addition to reporting on the operational effects on large-scale wind integration, NEWIS recommends potential corrective actions to mitigate adverse operating conditions created or exacerbated by the variability and uncertainty of wind power.

The results of the NEWIS ultimately will serve as the basis for regional policies and practices by the ISO, wind project owners, and interconnecting transmission owners and may result in changes to the ISO tariff, operating procedures, and manuals. The ISO will continue to work with stakeholders through the usual ISO stakeholder processes to implement the study's findings determined to be necessary, which may require modifying market and reliability rules necessary to facilitate the large-scale integration of wind resources.

Since the inception of the forward capacity market, a large amount of demand-side supply resources has been integrated into the resource mix to meet New England's capacity needs. The amount of demand resources procured by the ISO through FCM was about 1,800 MW for 2010, and increased to about 3,400 MW for 2014. This represents about 6 to 10 percent of the total

[19] *Load-serving entities* are electric utility distribution companies, except for municipally owned utilities, that sell basic electrical energy service to end-use customers.

[20] GE Energy Applications and Systems Engineering, et al, *Final Report: New England Wind Integration Study* (December 5, 2010), http://www.iso-ne.com/committees/comm_wkgrps/prtcpnts_comm/pac/reports/2010/index.html.

[21] The NEWIS methodology is discussed in more detail in RSP09, http://www.iso-ne.com/trans/rsp/2009/rsp09_final.pdf.

resources needed to satisfy New England’s Installed Capacity Requirements. Of these demand resources, about 60% are active demand resources that are dispatchable by the ISO. In order to reliably integrate the high level of demand resources into New England’s system, the ISO has created new procedures that integrate these resources into system planning, system operations, and market operations. The ISO’s real-time operational practices have been revised to improve the integration of large quantities of active demand resources. These changes include modifications to OP 4 and operator interfaces, the creation of demand-designated entities that can aggregate the operation of active demand resources, the establishment of dispatch zones for active demand resources, and the implementation of new communications infrastructure. Since summer 2010, the ISO has called upon these demand resources several times to mitigate tight the capacity situation, and they performed as expected.

APPENDIX

A Description of Resource Reliability Model

GE MARS uses a sequential Monte Carlo simulation to compute the reliability of a system comprised of a number of interconnected areas containing generation and load. This Monte Carlo process simulates the year repeatedly (multiple replications) to evaluate the impacts of a wide-range of possible random combinations of generator outages. The transmission system is modeled in terms of transfer limits (constraints) on the interfaces between interconnected areas. Chronological system histories are developed by combining randomly generated operating histories of the generating units and inter-area transfer limits with the hourly chronological loads. For each hour of the year, the program computes the isolated area margins based on the available capacity and demand in each area. GE MARS then uses a transportation algorithm to determine the extent to which areas with negative margin can be assisted by areas having positive (excess) margin, subject to the available transfer constraints between the areas. The program collects the statistics for computing the reliability indices, and proceeds to the next hour. After simulating all of the hours in the year, the program computes the annual indices and tests for convergence. If the simulation has not converged to an acceptable level, it proceeds to another replication of the study year; otherwise, it moves on to the next study year.

A.1.1 Load Model

A.1.1.1 Hourly Loads

GE MARS employs an 8760-hour chronological subarea load model. The load model currently used relies on an actual historical loads from the year 2002. This model is then scaled up to the summer peak for the future years being analyzed.

A.1.1.2 Load Forecast Uncertainty

The load forecast uncertainty was modeled on a seasonal basis, which accounts for the uncertainty due to weather variations.

A.1.1.3 Demand of Entities that are Not Members of NEPOOL

All the demands of entities within NEPOOL are modeled. The Maine Public Service (MPS) company demand is not modeled in this review because it is currently not a part of the ISO-NE Planning Coordinator area.

A.1.1.4 Demand Side Management Programs

The demand side programs included in this assessment are Demand Response resources that participate in New England’s forward capacity market. The active demand resources, including Real-Time Demand Response Resources and Real-Time Emergency Generation Resources, provide real-time peak load relief at the request of ISO New England during, or in anticipation of, expected operable capacity shortage conditions, where ISO-NE plans on implementing Operating Procedure No. 4, *Actions During a Capacity Deficiency*. The passive demand resources, which are non-dispatchable, include On-peak Demand Resources and Seasonal-Peak Demand Resources.

- An On-peak Demand Resource is a non-dispatchable measure that is not weather sensitive and its reduction in load will be measured during the hours ending 14:00 through 17:00, Monday through Friday on non-holidays during the months of June, July and August and the hours ending 18:00 through 19:00, Monday through Friday on non-holidays during the months of December and January.

- A Seasonal Peak Demand Resource is a non-dispatchable, weather-sensitive measure and its reduction in load will be measured during hours in which the actual, Real-Time hourly load for Monday through Friday on non-holidays, during the months of June, July, August, December, and January, as determined by the ISO, is equal to or greater than 90% of the most recent 50/50 system peak load forecast, as determined by the ISO, for the applicable summer or winter season.

- A Real-Time Demand Response Resource is a type of Demand Resource that is comprised of installed measures (e.g., products, equipment, systems, services, practices and/or strategies) on end-use customer facilities that: (i) curtail electrical usage in response to a Dispatch Instruction; and (ii) continue curtailing electrical usage until receiving Dispatch Instructions to restore electrical usage. Such measures include Load Management and Distributed Generation. The period of curtailment shall be consistent with Real-Time Demand Response Event Hours.

- A Real-Time Emergency Generation Resource is Distributed Generation whose Federal, State and/or local air quality permits limit operation in response to requests from the ISO to the times when the ISO implements voltage reductions of five percent of normal operating voltage that require more than 10 minutes to implement. A Real-Time Emergency Generation Resource must be capable of: (i) curtailing its end-use electric consumption from the New England grid within 30 minutes of receiving a Dispatch Instruction; and (ii) continuing that curtailment until receiving a Dispatch Instruction to restore consumption. The amount of Emergency Generators used to meet the ICR is currently limited to 600 MW, as stipulated in the market rules.

A.1.2 Resource Unit Representation

A.1.2.1 Unit Ratings

A.1.2.1.1 Definition

The ratings of all resources were based upon their seasonal Qualified Capacity values that are determined in accordance with the FCM market rules.

A.1.2.1.2 Procedure for Verifying Ratings

- Seasonal Claimed Capability of Generating Units

ISO-NE has the authority to initiate audits of all generating units to verify their Seasonal Claimed Capability. Audits are initiated by ISO-NE, ordering the generator output to be increased from its current operating level (if that level is below SCC) to its SCC. The unit is then required to hold the output at its SCC for a predefined time period. The required duration for a claimed capability audit is at least two hours and no more than eight hours, depending on the Capability Period and type of unit. In order to pass a claimed capability audit, a unit must demonstrate it can achieve average output greater than or equal to its Claimed Capability. Full details of the audit process can be found in the New England Manual for Installed Capacity, Manual M-20, Attachment D (Claimed Capability Audits) located at: http://www.iso-ne.com/rules_proceds/isone_mnls/index.html.

- Qualified Capacity Value under FCM

The determination of the Qualified Capacity value of a resource for participation in the FCA is outlined in Section III. 13 – Forward Capacity Market of Market Rule 1 located at: http://www.iso-ne.com/regulatory/tariff/sect_3/index.html.

The summer Qualified Capacity of a Generating Resource is calculated as the median of the most recent five summer Seasonal Claimed Capability (SCC) ratings with only positive, non-zero ratings included in the calculation.

The seasonal Qualified Capacity for Intermittent Power Resources, is calculated as the median of the net output during the Seasonal Intermittent Reliability Hours, of the most recent five summer periods.

The summer Qualified Capacity of a Demand Resource is rated using the summer seasonal Demand Reduction Value calculation which is dependent upon the Demand Resource type.

A.1.2.2 Unit Unavailability Factors

A.1.2.2.1 Unavailability Factors Represented

Forced outage rates, planned outages, and maintenance outages are represented for each resource in the reliability assessment.

A.1.2.2.2 Sources of Unavailability Factors

A 5-year, historical average of unit-specific forced outage assumptions is determined for each generating Resource, using its individual unit data of monthly EFORd[22] values from NERC's Generating Availability Data System (GADS). NERC GADS data submitted by generators to ISO-NE for the months of June 2006 through May 2011is used to create an EFORd value for each unit that submits such data. NERC Class Average data is used as a substitute for units that do not submit GADS data.

ISO-NE uses a 5-year historical average of actual generation during the daily peak periods as the expected Intermittent Power Resources' rating. This resource rating approach takes into account

[22] The calculation methodology of EFORd can be found in ISO-NE Manual 20 at http://www.iso-ne.com/rules_proceds/isone_mnls/M20/index.html.

the resources' physical and fuel availability. No additional availability factors are considered for these type of resources.

Passive demand resources, On-peak and Seasonal Peak demand resources, are considered as 100% available in the models. These resources are mainly from energy efficiency programs which are considered as always "*in service*" and as such are 100% available. Performance of active Demand Resources, the Real-Time Demand Response and Real-Time Emergency Generation Resources, are measured by actual response during historical events including audits and OP 4 events.

A weekly representation of a generator's scheduled outages is calculated for each unit, based on a 5-year historical average.

A.1.2.2.3 Maturity Consideration

NERC Class Average data is used as a substitute for immature units and new additions.

A.1.2.2.4 Tabulation of Unavailability Factors

Table 8 and 9 show the average unavailability factors used in this reliability assessment.

Table 8 Generating Resource EFORd and Maintenance Weeks by Category

Unit Type	Assumed Weighted EFORd(%)	Assumed Maintenance Weeks
Fossil	6.9	5
Combined Cycle	4.1	7
Diesel	6.8	1
Combustion Turbine	7.6	3
Nuclear	1.8	4
Hydro	3.5	4
Others	14.4	1
System	4.9	5

Table 9 Demand Resources EFORd Assumptions by Category

Type	Assumed Weighted EFORd(%)	Assumed Maintenance Weeks
On-Peak Demand Resources	0	0
Seasonal Peak Demand Resources	0	0
Real-Time Demand Response	16	0
Real-Time Emergency Generator	36	0

A.1.2.3 Imports and Exports Representation

Table 10 summarizes the capacity imports and exports with neighboring systems assumed for this assessment.

Table 10 Capacity Import and Export Assumptions (MW)

	2012	2013	2014	2015	2016
Hydro Quebec Import	1527	1624	1688	253	31
New York Import (via AC lines)	104	122	163	89	89
New York Export (via Cross Sound Cable)	100	100	100	100	100

A.1.2.4 Retirements & Deactivations

In this review, all resources that do not have capacity supply obligation are assume unavailable.

A.1.3 Representation Of Interconnected Systems

New England's directly interconnected neighboring bulk power systems are represented by tie benefits in this comprehensive review. These tie benefits are derived based on results of studies conducted with the GE MARS program. In these tie benefit studies, all the interconnected Areas are assumed to be at the 0.1 days/year resource adequacy criterion simultaneously. The Area's load, resource (including load and/or capacity relief assumed available from implementing emergency operating procedures) and transmission interface transfer limits are based on data that each Area has provided to NPCC for its studies. ISO-NE updates its tie benefit studies whenever it deems necessary. The tie benefit assumptions used in this review for 2012 to 2015 are based on results of the latest tie benefits studies. No tie benefits study has been conducted for year 2016, and the values of 2015 are assumed for 2016 in this assessment. Table 11 summarizes the tie benefit assumptions for this review.

Table 11 Assumed Tie Benefits From Neighboring System (MW)

Neighboring System	2012[23]	2013[24]	2014[25]	2015[26]	2016
Québec	984	922	960	1,048	1,048
New Brunswick	449	584	439	328	328
New York	319	194	290	300	300
Total	1,752	1,700	1,689	1,676	1,676

A.1.4 Modeling of Limited Energy Sources

New England's pumped storage and hydro-electric units were considered available to meet daily and monthly peak loads except when they are on planned maintenance or forced outages.

A.1.5 Modeling of Demand Side Management (DSM)

A description of the DSM programs were presented in Section A1.1.4.

A.1.6 Modeling of Resources

[23] http://www.iso-ne.com/committees/comm_wkgrps/relblty_comm/relblty/mtrls/2011/oct192011/index.html
[24] http://www.iso-ne.com/committees/comm_wkgrps/relblty_comm/relblty/mtrls/2010/mar172010/index.html
[25] http://www.iso-ne.com/committees/comm_wkgrps/relblty_comm/relblty/mtrls/2011/jan182011/index.html
[26] http://www.iso-ne.com/committees/comm_wkgrps/relblty_comm/pwrsuppln_comm/mtrls/2011/sep152011/index.html

Modeling of resources was as described in the above sections.

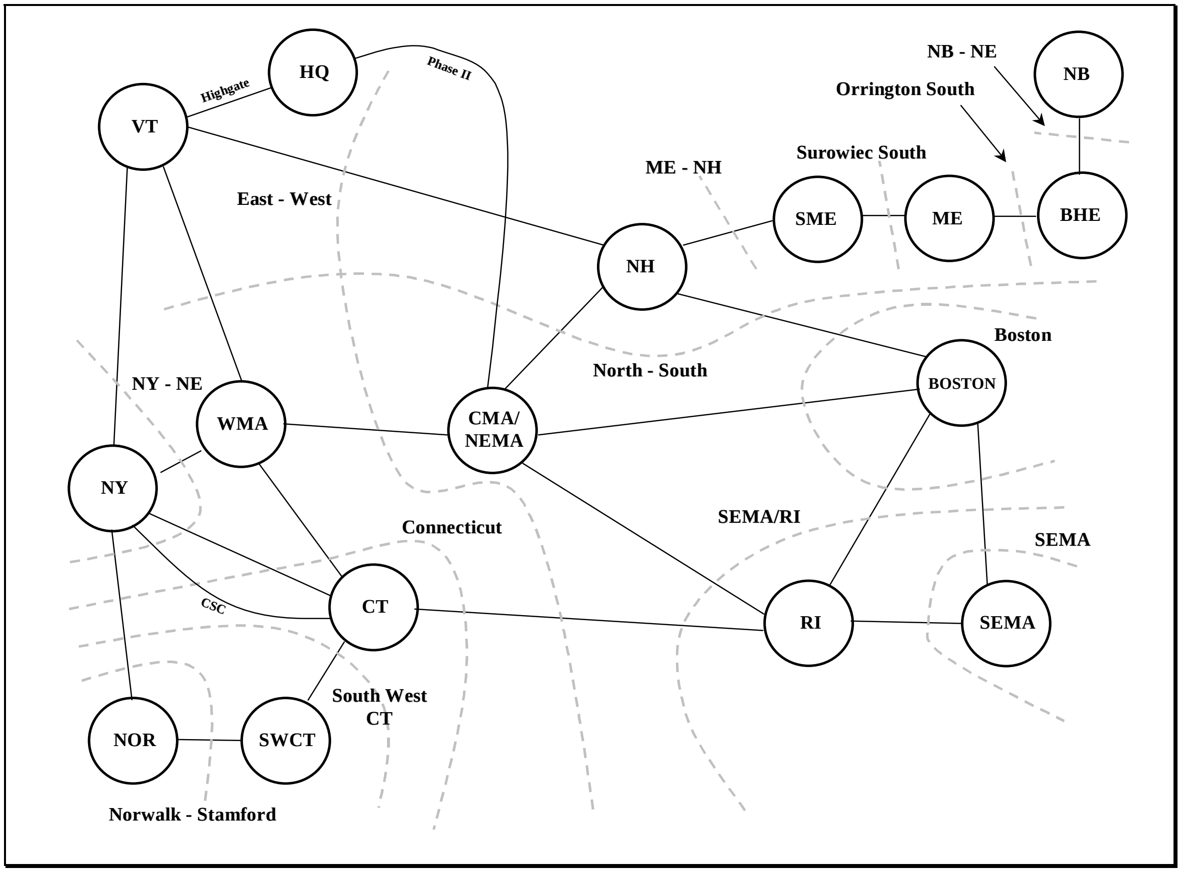
A1.7 Other Assumptions

Consistent with the ISO-NE's Regional System Plan, the New England system was modeled as 13 interconnected sub-areas, with predefined transmission interface limits between them. The transmission interface transfer capabilities between these sub-areas have been determined based on established ISO-NE and NPCC reliability criteria. These criteria are described, respectively, in ISO-NE Planning Procedure No. 3, *Reliability Standards for the New England Power Pool*, and NPCC Regional Reliability Reference Directory #1[27], *Design and Operation of Bulk Power System.* These criteria require that the interconnected bulk power supply system be designed for a level of reliability such that the loss of a major portion of the system, or unintentional separation of any portion of the system, will not result from reasonably foreseeable contingencies. Therefore, the system must be designed to meet representative contingencies as defined in those criteria. Contingencies are simulated to assess the potential for widespread cascading outages due to overloads, instability, or voltage collapse. New England's bulk power supply system must remain stable during and following the most severe of the contingencies specified in the criteria, with due regard to re-closing facilities and before making any manual system adjustments. Voltages, line loadings, and equipment loadings must be within normal limits for pre-disturbance conditions, and within applicable emergency limits following the contingencies specified in the criteria. Disturbances in New England must not adversely affect other NPCC Control Areas and vice versa. Conversely, the loss of small portions of the system may be tolerated, provided the reliability of the overall interconnected system is not jeopardized.

The transmission interfaces used in the reliability analysis represent potential limiting areas of New England's transmission system, which may become constrained under a variety of system conditions, generation patterns, or transmission topology. The most limiting transmission facility and critical contingency which limits the interface transfer, may change depending on unit dispatch, load level, load distribution, and transmission configuration. For modeling purposes, these interface limits are shown as static. Interfaces composed of one or more transmission facilities have been defined to gauge the amount of power which can be transferred between or through various areas before a transmission limitation is reached. Figure 4 shows the New England sub-area representation.

[27] https://www.npcc.org/Standards/Directories/Directory%201%20-%20Design%20and%20Operation%20of%20the%20Bulk%20Power%20System%20Full%20Member%20Approval%20December%2001,%202009%20GJD.pdf

Figure 4 New England Sub-Area Representation



Sub-areas

BHE	-	Northeastern Maine
ME	-	Western & Central Maine / Saco Valley, New Hampshire
SME	-	Southeastern Maine
NH	-	Northern, Eastern, & Central New Hampshire / Eastern Vermont & Southwestern Maine
VT	-	Vermont / Southwestern New Hampshire
BOSTON	-	Greater Boston, including North Shore
CMA/NEMA	-	Central Massachusetts / Northeastern Massachusetts
WMA	-	Western Massachusetts
SEMA	-	Southeastern Massachusetts / Newport, Rhode Island
RI	-	Rhode Island / bordering Massachusetts
CT	-	Northern and Eastern Connecticut
SWCT	-	Southwestern Connecticut
NOR	-	Norwalk / Stamford, Connecticut

NB, HQ and NY represent the New Brunswick, Québec and New York balancing authority respectively.

Interface Limits (MW)

Interface or Interface Group	Interface Limit (MW)
New Brunswick to NE	700
Orrington South	1,200
Surowiec South	1,150
Maine – NH	1,600
	1,575 (Year 2015)
	1,550 (Year 2016)
North to South	2,700
Boston Import	4,900
	4,850 (Year 2014)
SEMA Export	No Limit
SEMA / RI Export	3,000
	3,300 (Year 2016)
East to West	2,800
	3,500 (Year 2016)
Connecticut Import	2,500
	2,600 (Year 2014)
	3,400 (Year 2016)
Southwestern CT Import	3,200
Norwalk / Stamford Import	1,650
New York / New England Import	1,400 (summer) 1,875 (winter)
HQII Import	1,400
Highgate Import	200
Cross Sound Cable Import	0