



November 16, 2017

Via Electronic and U.S. Mail

Pamela G. Monroe, Administrator
New Hampshire Site Evaluation Committee
21 South Fruit Street, Suite 10
Concord, NH 03301-2429
pamela.monroe@sec.nh.gov

Re: Docket No. 2015-06 – Joint Application of Northern Pass Transmission, LLC and Public Service Company of New Hampshire d/b/a Eversource Energy for a Certificate of Site and Facility

Dear Ms. Monroe:

Enclosed for filing with and consideration by the New Hampshire Site Evaluation Committee (“the Committee”) in the above-referenced matter please find a report entitled “Analysis of Greenhouse Gas Emissions Impacts: New Class I Resources vs. Existing Large Hydro” (“the report”). The report was referenced during the testimony of Messrs. Weiss and Newell at the October 26, 2017 afternoon hearing in the above-captioned matter, and has been designated Exhibit ID JM 307.

The undersigned confirms that this is an independent report prepared by ESAI Power LLC, a leading research firm that systematically analyzes the physical, financial, and environmental aspects of the Northeast wholesale electricity markets and provides periodic forecasts for the major energy hubs and zones in each of the Northeast power markets. The report examines the environmental impacts of proposed transmission projects and associated sources of supply bid into the Massachusetts Clean Energy RFP, including those that traverse New Hampshire.

ESAI welcomes any questions pertaining to this report from the Committee.

Respectfully submitted,

A handwritten signature in blue ink, appearing to read "Scott W. Niemann", with a long horizontal line extending to the right.

Scott W. Niemann

Director and Principal, ESAI Power LLC

cc: Service List (by electronic mail)



Analysis of Greenhouse Gas Emissions Impacts:

New Class I Resources vs. Existing Large Hydro

A Study Prepared by
ESAI Power LLC

For
GridAmerica Holdings Inc.

September 2017

ESAI
Power LLC

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DISCLAIMER

This report was prepared by ESAI Power (“ESAI”) for GridAmerica Holdings Inc., in connection with development of the Granite State Power Link HVDC transmission Project and the New England Renewable Link transmission (“the Projects”).

The conclusions and observations contained herein attributed to ESAI constitute the opinions of ESAI. For a complete understanding of the conclusions and opinions, this report should be read in its entirety. To the extent that statements, information and opinions provided by GridAmerica Holdings Inc., or others have been used in the preparation of this report, ESAI has relied upon the same to be accurate. While we believe the use of such information provided by others is reasonable for the purposes of this report, no assurances are intended and no representations or warranties are made. This report is not a substitute for any party’s own due diligence in evaluating any potential transaction or project, whether or not such transaction or project was the underlying purpose of this report. ESAI does not opine upon the merits or future outcome of any transaction or project.

This Report is effective as of the date hereof and ESAI disclaims any obligation to update it.

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1. EXECUTIVE SUMMARY

1.1. Overview of ESAI Analysis and Report

ESAI Power LLC (ESAI) was retained by GridAmerica Holdings Inc. (GridAmerica), to assess the impact of the Granite State Power Link (GSPL) and New England Renewable Energy Link (NRL) transmission facilities on Greenhouse Gas (GHG) Emissions in the Northeast U.S. power markets. GSPL will be a High Voltage Direct Current (HVDC) transmission facility that will provide capacity to transmitting 1,200 MW of clean energy from the international border between Quebec and Vermont to an existing substation located in Monroe, New Hampshire. The project will rely heavily on existing transmission corridors and upgrades to existing infrastructure. NRL is a proposed controllable transmission line connecting the Alps substation in New York with the Berkshire substation in Massachusetts.

Energy delivered on the GSPL and NRL lines was offered in response to the 83D RFP, which seeks 9.45 TWh of clean energy that will apply towards meeting the requirements of the Massachusetts Global Warming Solutions Act (GWSA). The offer for GSPL includes 4.2 TWh of wind energy from new sources in Quebec and would provide approximately half of the target energy. Additional capacity on GSPL will be available on a merchant basis to support additional imports of clean energy from Quebec and elsewhere in eastern Canada. The NRL line will provide 500 MW of firm, hourly energy deliveries to New England, backed by new wind and existing small hydro resources in New York. The deliveries on NRL will provide 4.38 TWh of clean energy to Massachusetts. In combination, the two projects could provide all or most of the 9.45 TWh sought under the RFP.

GridAmerica asked ESAI to estimate the change in GHG emissions that will result from the deliveries of clean energy on GSPL and NRL. The deliveries of renewable energy on the two projects will displace generation for conventional resources in New England, resulting in a net reduction in GHG emissions. Because most of the renewable energy will be generated from new resources that would not be built without a contract under the 83D RFP, the deliveries on the transmission lines will provide a net increase in renewable energy for the region.

For comparison, ESAI has also estimated the change in GHG emission that would occur with the addition of an HVDC transmission line that delivers power from hydro facilities in Quebec in or near operation. Hydro Quebec (HQ) currently exports all of its surplus energy and has sufficient transmission capacity to neighboring markets to continue to export its expected future surplus. Hence, the energy from hydro generation in Quebec will be used to meet native load or exported regardless of the outcome of the 83D RFP and total annual exports of hydro energy will not change as a result of new transmission built through the RFP. Expanded transmission to New England will instead affect the portion of the total exports that are sent to the New England region. Any increase in deliveries of Quebec hydro energy to New England will require an equivalent reduction in exports of hydro power on other existing tie lines. The reduction in exports on those other tie lines will result in an increase in other generation. To the extent that conventional, fossil-fuel generation is increased to replace the energy that otherwise would have been imported from Quebec, GHG emissions will

increase and offset the reductions facilitated by the clean energy deliveries on the new facility. Hence, although total GHG emissions may decrease within New England and Massachusetts, GHG emissions will increase in other regions.

The report begins with a brief description of the GSPL and NRL projects and a summary of the key results and conclusions. Second, the report provides a background discussion about the New England market and the projects that are likely to provide competing responses to the RFP. A description of the analytical approach is provided next, followed by a discussion of the results. An appendix provides additional detail on the key market modeling assumptions.

ESAI's projections and conclusions reflect expectations about market rules, market conditions and analytical assumptions as of June 2017.

1.2. Project Descriptions

1.2.1. GSPL

GSPL will have a capacity of 1,200 MW and will facilitate the transfer of up to 10,300 GWh of around-the-clock energy at an availability of 98 percent. GridAmerica expects to deliver Canadian clean energy wheeled from wind and hydro resources in Quebec through a combination of contracted and merchant sales. The contracted sales will include the output of 1,200 MW of new wind generation added in Quebec. The wind resources are expected to achieve a capacity factor of 40 percent, allowing delivery of approximately 4.2 TWh. GSPL will deliver all the energy from the contracted wind at the time of production, with hourly flows of contracted power following the wind generation production profile. Capacity on the line in excess of the output of the wind facilities will be available for merchant power sales on an hourly basis.

The GSPL project will consist of new HVDC transmission from the U.S.-Canada border at the town of Norton in northeastern Vermont extending approximately 60 miles southward to a proposed DC/AC converter station on GridAmerica property in Monroe, New Hampshire. The converter station will be adjacent to the existing Comerford substation. The interconnection will likely require New England Power Company to upgrade the existing 230 kV AC corridor from Comerford southwards to a higher voltage of 345 kV to accommodate flows from Quebec.

1.2.2. NRL

The NRL project will consist of a new controllable 345 kV AC line that will transfer energy from eastern New York to western Massachusetts. The new 345 kV line will parallel an existing line using the existing pathway from the 345 kV Alps substation in New York (13 miles east of Albany) to the 345 kV Berkshire substation in Massachusetts (5 miles east of Pittsfield). A phase angle regulator will be installed in the Alps substation and will direct flows sourced from the AC system in New York to the Berkshire substation in Massachusetts. The phase angle regulator provides control of flows from Alps to Berkshire and ensures transfer of the contracted clean energy into New England. All of the energy delivered via NRL will be come from renewable sources, including 500

MW of new generating capacity from facilities that are in the development phase and will qualify as Class I resources under the Massachusetts Renewable Portfolio Standards.

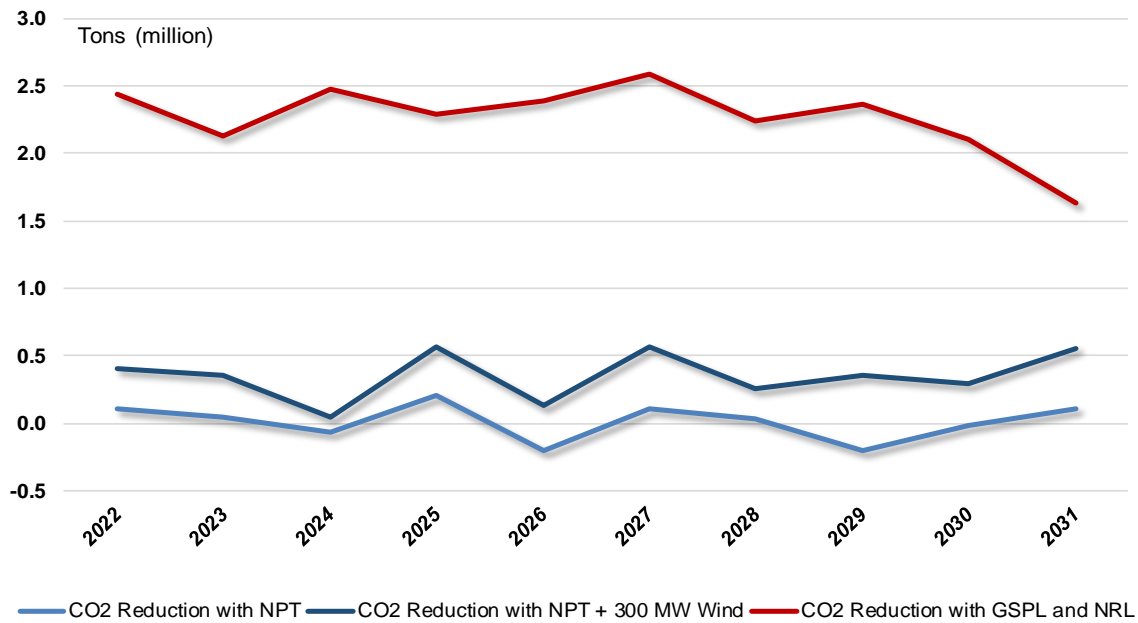
1.3. Summary of Results and Conclusions

Over the 10 year period 2022-2031, the combined addition of the GSPL and NRL lines will result in a decrease in GHG emissions of 4.5 million tons for Massachusetts and 27.8 tons for New England overall. Additional changes in emission in New York, Ontario, PJM, and MISO bring the region-wide emissions reductions from GSPL and NRL to a total of 22.6 million.

A transmission project delivering Canadian hydro without additional new renewable generation, would result in similar GHG emission reductions for New England, but the reductions would be offset by higher GHG emissions in other markets throughout the broader region where additional thermal generation is needed to replace the imported power from Quebec that is delivered to New England on the new line. In other words, a new line would result in imports that would reduced gas-fired generation in New England, but also require more gas-fired generation in other markets where imports would decrease. Although the 1,090 MW Northern Pass Transmission (NPT) project would result in estimated GHG emission reductions of 3.6 million tons for Massachusetts and 25.5 million tons for New England, offsetting increases in other regions bring the net impact down to 0.1 million tons over ten years. If NPT is added along with 300 MW of new wind capacity in Quebec, the net, region-wide impact over ten years would be a reduction in GHG emissions of 3.5 million tons.

Figure 1 shows the annual net change in GHG emissions under these scenarios for both the combined GSPL and NRL projects, and the NPT project.

Figure 1: Net GHG Emission Impacts



2. OVERVIEW OF QUEBEC EXPORTS

GSPL will connect the New Hampshire zone of the ISO New England (ISO-NE) market with the HQ system, providing 1,200 MW of additional capacity for exports from Quebec. Two existing connections between HQ and ISO-NE provide 1,600 MW of firm capacity for interchange between the markets.¹ Due to attractive pricing in the New England market, the capacity on these existing tie lines is highly utilized. The addition of GSPL will allow more of the surplus energy available in HQ and eastern Canada to reach the ISO-NE market. The NPT project would also connect HQ and New Hampshire, providing 1,090 MW of additional tie line capacity.

As shown in Figure 2, the HQ system is also interconnected via HVDC links to the New York ISO (NYISO), New Brunswick, and Ontario regional power markets. Table 2 shows the capacity available on each tie line for exports from and imports to the HQ system. As discussed below, Hydro Quebec is expected to have surplus hydro capacity available to support approximately 36.5 TWh of net exports over these tie lines. Figure 3 shows the historical level of exports from HQ. Additions of new hydro power generating capacity in Quebec have supported substantial increases in HQ exports. The generating capacity on the HQ system is almost entirely hydro, providing a fixed amount of energy each year that is available for meeting Quebec demand and exports. The hydro capacity in Quebec includes a significant amount of pondage, allowing the energy to be stored and produced when needed to meet demand in Quebec or for export. In addition to its internal hydro capacity, Quebec has access to almost all of the output from the 5.4 GW Churchill falls complex in Newfoundland and Labrador. Quebec has imported approximately 30 TWh annually from Churchill falls. Surplus capacity and energy on the system still allow significant exports of power, even during the winter months.

The Quebec hydroelectric capacity, along with Churchill Falls, wind generation in Quebec, and a small amount of thermal capacity provides the province with access to approximately 218 TWh of energy annually. ESAI's analysis of CO₂ impacts assumes average annual exports of approximately 36.5 TWh of surplus hydropower to Ontario, New England, New York, and New Brunswick each year. This assumption accounts for completion of two additional projects under construction in Quebec, Romaine units 3 and 4, will provide another 3.3 TWh of energy by 2020,² along with projected growth of approximately 4 TWh in purchases from other renewable sources (excluded any purchases under the 83D RFP). Quebec internal native load is expected to grow by 8 TWh to 189 TWh by 2026, consuming the projected growth in production capability and expected purchases.

¹ The 1,600 MW total includes 1,400 MW from Phase 2 and 200 MW from Highgate. The thermal rating of the Phase 2 line is sufficient to allow additional flows into New England above 1,400 MW, but the firm capacity is limited to 1,400 due to the reliability impacts under a line outage contingency.

² Romaine 3 (Online in 2017) will have capacity of 245 MW and expected output of 2 TWh and Romaine 4 (online by 2020) will capacity of 245 MW and expected output of 1.3 TWh (See HQ Strategic Plan 2009-2013, p. 21)

Table 1: Quebec Load and Available Energy Supply

	2016 Actual	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Supply Available (TWh)											
HQ Hydropower Generation	172.0	173.0	174.0	174.0	175.3	175.3	175.3	175.3	175.3	175.3	175.3
Purchased Hydropower	33.2	33.5	33.7	33.9	34.0	34.2	34.4	34.6	34.8	34.9	35.1
Other Purchases & Production	12.0	11.8	12.2	12.5	12.9	13.2	13.6	13.9	14.3	14.6	15.0
Total	217.2	218.3	219.8	220.4	222.2	222.7	223.3	223.8	224.3	224.8	225.4
Quebec Native Load (TWh)	182.3	181.1	182.8	183.9	185.5	184.5	185.5	186.5	188.1	188.2	189.0
Surplus Available for Export (TWh)	34.9	37.2	37.0	36.5	36.7	38.2	37.8	37.3	36.2	36.6	36.4

The surplus energy available from the HQ system for export to Ontario and the U.S. markets is being sold in order to maximize revenue over the course of the year, given the limitations on the export capacity on each tie line. The existing tie lines have a combined capacity of 5.9 GW, which is sufficient to support over 50 TWh of annual exports. Recent exports have totaled approximately 30 TWh, based on existing surplus levels, but higher levels are feasible. In the first quarter of 2017 alone, HQ exports totaled 10 TWh.

Increasing the transmission capacity available for exporting from HQ will not increase the total export amount unless new capacity is also added to the HQ system, beyond the new units already under construction at Romaine. Load growth over the next ten years will also offset the additional generation from the units under construction at Romaine. However, the increased transmission capacity will allow more of the available 36.5 TWh to reach the export markets during the periods when prices are the highest. Although there is ample transmission capacity to export the full 36.5 TWh surplus and HQ does not need to spill water from its dams, the tie lines are constrained during peak periods. With the currently available transmission capacity, HQ must store the energy and deliver a significant portion of the available surplus to New York and Ontario during periods when prices are relatively low.

The capacity provided by GSPL will be very highly utilized during most on-peak hours, when the existing ties to New England are already fully utilized. The contracted wind energy that will be delivered on GSPL will require approximately 40 percent of the line capacity, on average. The output of these new wind facilities will add to the existing energy available for export (approximately 36.5 TWh). The energy used to support the remaining merchant capacity on GSPL will need to be supported by reduced exports to (or increased imports from) New York and Ontario.

Figure 2: Northeast Wholesale Power Markets

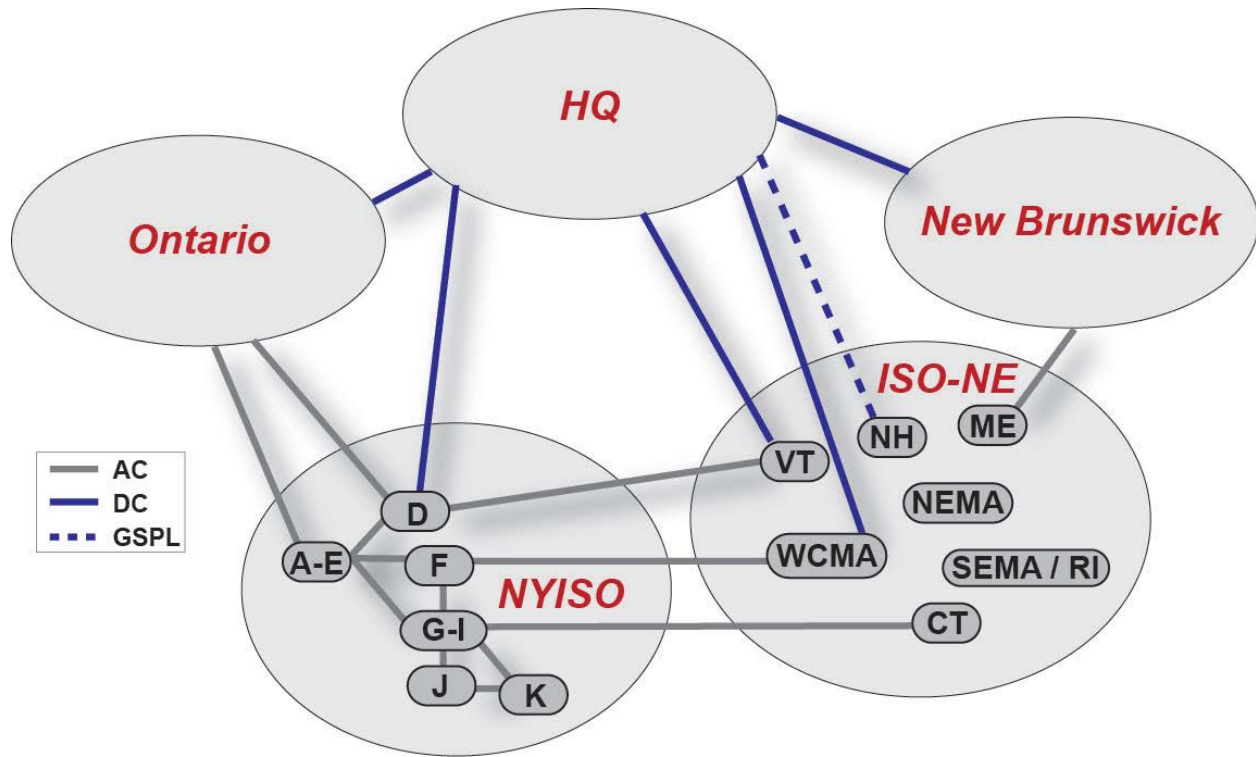
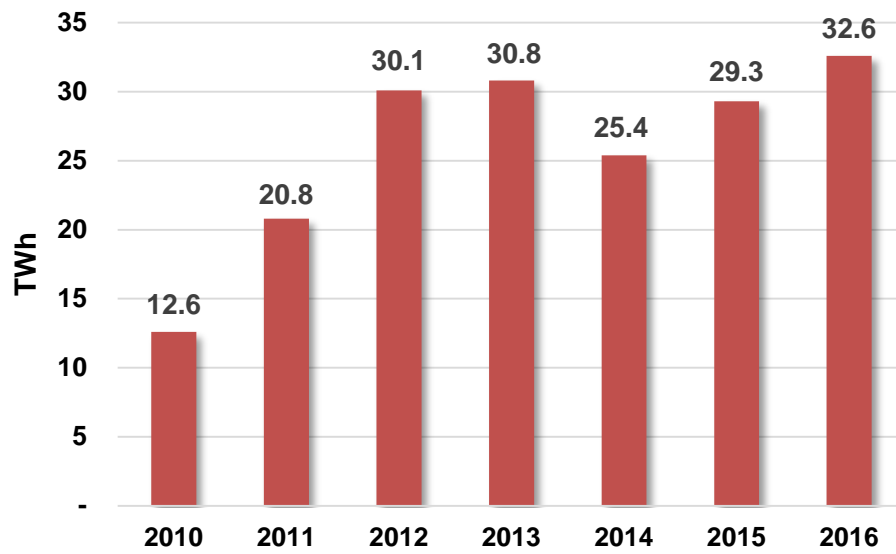


Table 2: HVDC Ties to the HQ System

Interconnection		Export Capacity (MW)	Import Capacity (MW)	2016 Net Exports (TWh)
New England				
Highgate	VT Zone	200	200	
Phase 2 (Sandy Pond	WCMA Zone	1,400	1,400	
Total		1,600	1,600	15.6
New York				
Chateauguay	Zone D (North)	1,500	1,000	8.5
New Brunswick				
		770	400	1.6
Ontario				
North DC Ties		1250	1250	
Beauharnois		800	400	
Total		2,050	1,650	4.6

Figure 3: Historical Net Exports by Hydro Quebec



3. APPROACH AND MODELING METHODOLOGY

3.1. Scenarios Examined

ESAI estimated the change in emissions attributable to the GSPL and NRL projects by comparing total emissions for a case in which the projects are selected under the 83D RFP to a status quo case without the RFP. In the status quo case, additional renewable capacity was added in order to partially meet the RPS requirements of the New England states. However, ESAI assumed that without the RFP, no transmission projects to facilitate delivery of additional renewable capacity from Northern New England or neighboring markets would be completed. ESAI also estimated the emissions impact of the Northern Pass Transmission (NPT) project by comparing total emissions in a scenario with NPT in service to the status quo case. The change in emissions associated with the NPT project illustrates the impact of additional imports supported by existing hydro in Quebec, both alone and with 300 MW of new wind capacity, and provides a point of comparison for the GSPL and NRL projects, for which imports will be supported by new renewable capacity.

Specifically, ESAI estimated the system dispatch for New England and neighboring regions under a status quo case and three additional scenarios:

- A status quo case, without the 83D RFP, in which the pace of renewable additions is constrained by the existing transmission system;
- A case with NRL and GSPL added, along with
 - New wind capacity in Quebec to support 4.2 TWh of contracted deliveries on GSPL
 - 500 MW of new wind capacity in New York, but no additional renewable capacity in New York beyond what is included in the status quo case.
- A case with NPT delivering firm energy from Quebec, but no additional renewable capacity beyond the status quo case.
- A case with NPT delivering firm energy from Quebec, partially supported by 300 MW of new wind additions in Quebec.

The cases are summarized in Table 3 below.

Table 3: Summary of Market Scenarios

	Status Quo Case	GSPL+NRL Cases	NPT Cases
Transmission Additions	None	GSPL with contracted delivery of 4.2 TWh of wind plus merchant deliveries as economic; NRL with 500 MW of firm renewable energy from New York	NPT with firm delivery of 1,090 MW of Quebec hydro
Quebec Hydro Exports (All Markets)	Available surplus scheduled on existing tie lines to New England, New York, New Brunswick, and Ontario to maximize total revenue from export sales	Available surplus scheduled on existing tie lines and merchant capacity on GSPL to maximize total revenue from export sales	Available surplus schedules such that 8.5 to 9.5 TWh (depending on amount of new wind added in HQ) dedicated to firm deliveries on NPT and remaining energy scheduled to maximize total revenue from export sales
Wind Additions in Quebec	None	1,200 MW of wind with a 40 percent capacity factor, committed for export on GSPL	Two Cases: (a) None (b) 300 MW at 40% capacity factor
Total Quebec Exports	Average of 36.5 TWh annually, all hydro (See Table 1 for annual values through 2026. Exports of 36 TWh assumed for 2027-2030)	Status Quo Exports plus 4.2 TWh of firm wind	Status Quo Exports plus up to 1.05 TWh from wind
New England Renewables Added Outside 83D RFP	Nameplate generic renewable capacity additions of: 2017: 25 MW 2018: 28 MW 2019: 126 MW 2020: 100 MW 2024: 200 MW 2025: 200 MW 2026: 150 MW 2027: 150 MW 2028: 75 MW	Same as status quo case	Same as status quo case
New York Renewable Additions	New renewables additions each year to support 1.4 TWh of new production	Status Quo additions plus an additional 1.8 TWh by 2022	Same as status quo case

3.2. Aurora Market Model

ESAI utilized its AuroraXMP production cost model to estimate the dispatch of the ISO-NE, NYISO, Ontario, PJM, and MISO systems in each of the scenarios discussed above. AuroraXMP is deployed with ESAI's proprietary input assumptions and is used to estimate the least-cost, chronological dispatch of the system for all 8,760 hours of each year. The dispatch accounts for the marginal production cost and operational parameters of each generation resource, hourly demand, and, transmission constraints. The key market assumptions used for this study are discussed below.

3.2.1. Scheduling of HQ Exports

Based on HQ historical exports, as reported in the HQ Annual Reports, as well as expansion plans and demand growth discussed in the HQ 10-year Strategic Plan, ESAI assumed that on average 36.5 TWh of surplus hydro will be available for export for Quebec to Ontario and the U.S. markets each year. This 36.5 TWh of energy is surplus energy that is not needed to meet Quebec demand. Because the HQ system consists almost entirely of hydro capacity, its annual energy production is determined by hydrological conditions rather than economics. Although the HQ system has a significant amount of storage capacity that allows the generation to be shaped over time in response to internal demand and export prices, the total production over time is fixed by the amount of water available. The existing external transmission ties connecting HQ to neighboring markets is sufficient to support export of the full 36.5 TWh projected to be available each year plus approximately another 14 TWh. Hence, a new transmission line to New England will not lead to an increase in total exports of hydro power from Quebec. Rather, exports on the new line will be supported by reductions in exports on other tie lines, or in the case of GSPL, by new wind capacity added to the HQ system.

ESAI forecasted the distribution of the 36.5 TWh of exports across the markets and over time by finding the schedule of deliveries to each market that maximizes total export revenue for sellers in Quebec. In the Status Quo case, only the existing tie lines were assumed to be available. In the cases with GSPL or NPT added to the system, exports on those new line results in a decrease in net exports on the other, existing tie lines. For example, in the case with firm exports of 1,090 MWh on NPT, the total sales of 9.5 TWh on NPT require an equivalent reduction in exports on the other tie lines. Optimal scheduling of the exports will result in those reductions occurring during the hours when prices in the other markets are lowest. So, exports during off-peak hours to New York and Ontario in the Status Quo case might be redirected for delivery on NPT at higher prices.

The figures below show the 2025 monthly net exports to each market for each case. The total exports equal 36.6 TWh for the Status Quo and NPT Cases, while the GSPL+NRL Case also includes the 4.5 TWh from new wind facilities in Quebec, so the total exports are 41.1 TWh.

Figure 4: 2025 Quebec Export Schedule, Status Quo Case

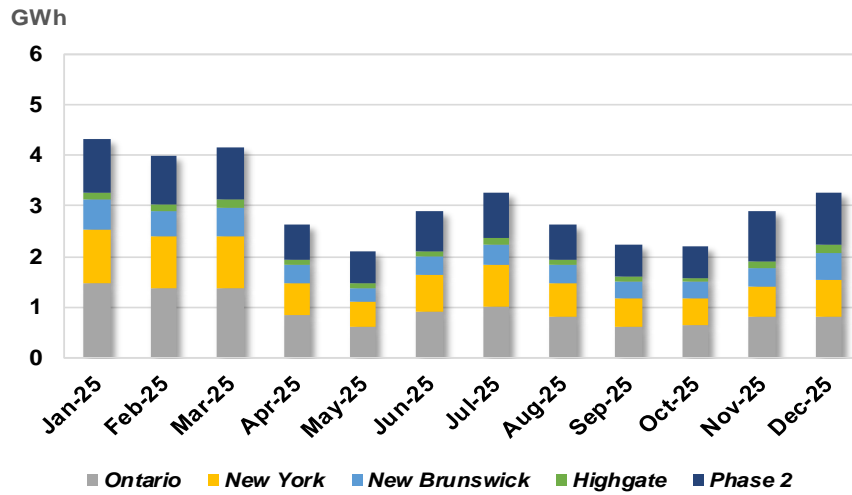


Figure 5: 2025 Quebec Export Schedule, GSPL+NRL Case

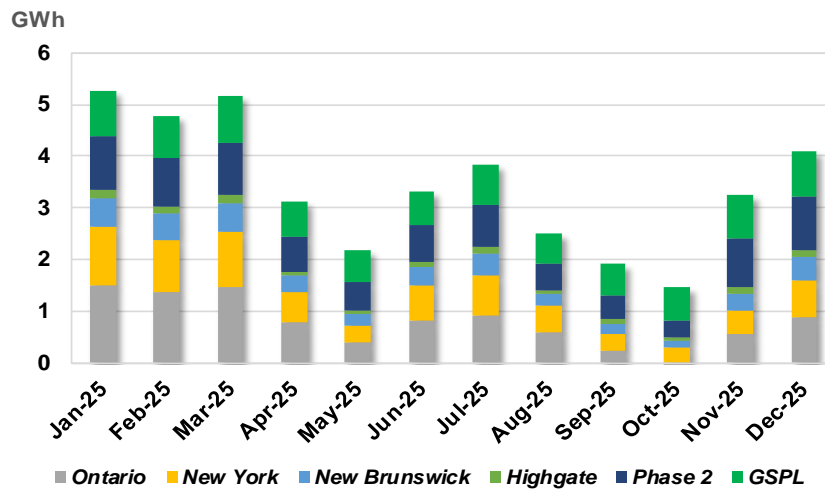


Figure 6: 2025 Quebec Export, NPT Case (without New Wind)

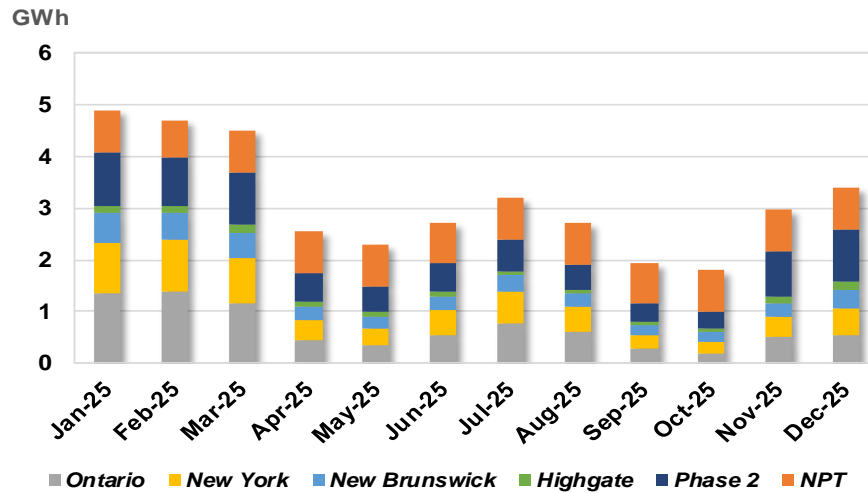
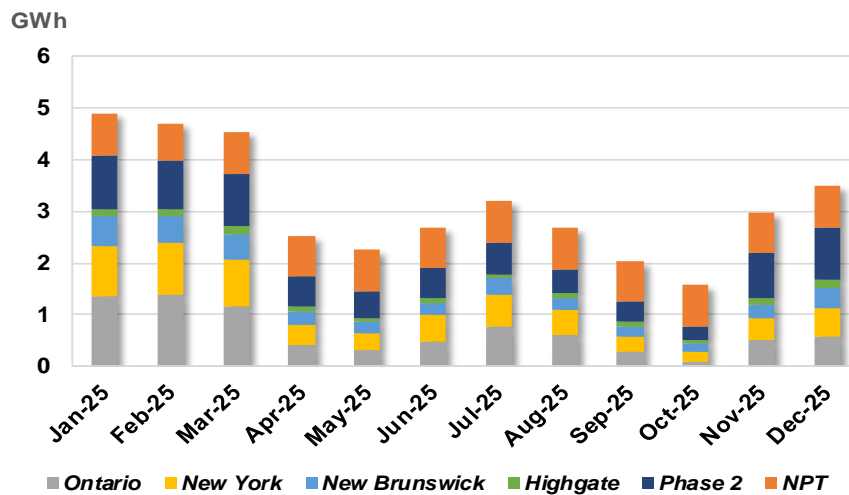


Figure 7: 2025 Quebec Export, NPT Case (with 300 MW New Wind)



3.2.2. Market Assumptions

Details of the assumptions used in this study are provided in the Appendix, Section 5. Unless otherwise noted, the same assumptions apply to all cases. A summary overview is provided below:

1) *New Generation & Retirements*

- a. Retirements include all announced retirements and non-price retirements registered in the Forward Capacity Auctions held to date. This includes projected retirements of Brayton Harbor in 2017 and the Pilgrim nuclear plant which is assumed to retire in 2019. Also included is the retirement of the 400 MW Bridgeport Harbor coal facility in 2021. Other retirements are detailed in the Appendix, totaling over 4,000 MW from 2014 to 2021. The Merrimack Coal Plant is assumed to retire before COD for GSPL.

- b. New generation additions through 2017 include renewable resource additions from wind, solar, hydro, landfill gas and biomass. Upcoming major additions include the Footprint Power combined cycle plant in 2017 (NEMA) and the Towantic combined cycle plant in 2018 (CT). Additional simple cycle peaking facilities are also expected at Medway and Wallingford in 2018. The Forward Capacity Auction for 2019/2020 cleared over 1,300 MW of new capacity including combined cycle capacity in Rhode Island and Connecticut (Clear River and Bridgeport Harbor) as well as simple cycle capacity in SEMA (Canal). The Forward Capacity auction for 2020/21 did not clear any significant new capacity but did clear additional demand response resources, mostly energy efficiency.
- 2) *Energy Demand (Load Forecast)*
- a. Energy demand and peak load forecasts for ISO-NE were obtained from the ISO-NE 2017 Capacity, Energy, Loads and Transmission (CELT) Report issued in April 2017.
 - b. NYISO peak load and energy demand are as forecasted and reported in the 2017 Gold Book.
 - c. The Ontario peak load forecast comes from the 2013 IESO Long Term Expansion Plan (LTEP). Although a more current LTEP is not yet available, the IESO has recently provided forecasts for several potential growth scenarios. The 2013 LTEP forecast falls in the middle of the range of potential growth rates shown in those updated scenarios.
- 3) *Transmission Development*
- a. ESAI tracks transmission development and models all viable transmission projects in New England as part of its energy modeling efforts. The following projects are representative of projects recently completed and included in ESAI's energy models:
 - The Maine Power Reliability Program (MPRP) project increases transfer capacity across interfaces in Maine.
 - The New England East-West Solution upgrades (NEEWS) helps alleviate congestion on the East-West interface and Connecticut Import Interfaces.
 - The North Shore upgrades, which allow additional imports into NEMA.
- 4) *Fuel Prices*
- a. The major fuel driver in New England is natural gas. ESAI utilized forward market gas prices as of June 27, 2017.

5) *Emissions Allowance Prices*

- a. ESAI includes the cost of emissions allowances in its energy model outlooks. This includes allowance prices for SO₂, NO_x, and RGGI³.

6) *Renewable Portfolio Standards*

- a. Renewable Portfolio Standards for each state are assumed to be consistent with current laws and regulations. The Massachusetts annual 1.0 percent increase will continue past 2020 unless revoked by the legislature. ESAI has assumed that the annual increases would eventually be capped at 35 percent in 2040.
- b. ESAI includes solar additions consistent with state programs such as Massachusetts SREC programs. ESAI includes behind-the-meter solar consistent with ISO-NE projections.
- c. Also included are wind and renewable projects that will enter the market as a result of awards in the Clean Energy RFP.
- d. Generic renewable additions are included such that the market is slightly short against regional RPS requirements through 2026 and balanced thereafter.

³ RGGI – Regional Greenhouse Gas Initiative. RGGI is a program that applies to nine states (including all of the New England states) that seeks to limit CO₂ emissions through a cap and trade mechanism. ESAI maintains a proprietary outlook for RGGI prices.

4. GREENHOUSE GAS EMISSIONS

Table 4 shows the difference in GHG emissions between the Status Quo Case and the scenario with GSPL and NRL, along with the new renewable additions to support the contracted deliveries on each line. Over the first ten years with the projects in service, region-wide emissions will decline by 22.6 million tons.

Table 4: Reduction in GHG Emissions with GSPL and NRL (000 Tons)

	New England	New York	Ontario	PJM	MISO	Total
2022	2,696	(712)	367	8	79	2,438
2023	2,891	(774)	364	(475)	125	2,130
2024	2,919	(625)	366	(331)	145	2,475
2025	3,052	(767)	341	(532)	202	2,296
2026	2,840	(508)	314	(277)	20	2,390
2027	3,079	(878)	346	(103)	138	2,583
2028	2,832	(774)	305	(46)	(75)	2,243
2029	2,696	(836)	335	(26)	199	2,368
2030	2,561	(806)	377	(255)	221	2,099
2031	2,267	(766)	265	(271)	134	1,629
10 Year Total	27,835	(7,446)	3,381	(2,307)	1,188	22,651

Table 5 shows the change in emissions that would result from importing 1,090 MW of Quebec hydro on the NPT line and Table 6 shows the impact from NPT plus 300 MW of new wind in Quebec. Importing the clean energy to New England would displace fossil-fueled generation on the ISO-NE system, reducing GHG emission in the New England states. However, because the imports of clean energy on NPT would displace exports from Quebec to New York and Ontario, more fossil-fueled generation is needed in those markets and the net impact on total GHG emission throughout the broader region would be close to zero without wind additions.

Table 5: Reduction in GHG Emissions with NPT (000 Tons)

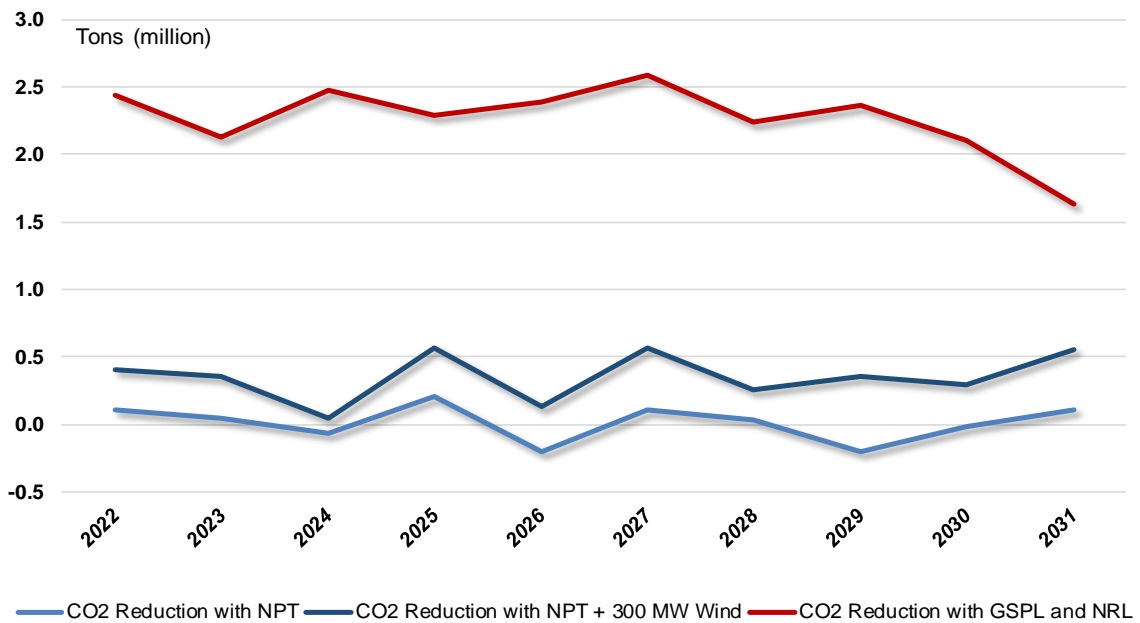
	New England	New York	Ontario	PJM	MISO	Total
2022	2,746	(1,047)	(1,178)	(129)	(278)	113
2023	2,606	(1,082)	(1,108)	(143)	(229)	44
2024	2,644	(1,289)	(1,045)	(118)	(255)	(63)
2025	2,665	(1,162)	(1,026)	(271)	(3)	203
2026	2,594	(1,110)	(935)	(653)	(103)	(206)
2027	2,683	(1,381)	(841)	(160)	(189)	112
2028	2,479	(1,315)	(866)	(235)	(30)	33
2029	2,646	(1,388)	(828)	(806)	177	(199)
2030	2,347	(1,153)	(842)	(444)	81	(10)
2031	2,106	(733)	(861)	(333)	(75)	103
10 Year Total	25,516	(11,661)	(9,530)	(3,292)	(903)	130

Table 6: Reduction in GHG Emissions with NPT + 300 MW Wind (000 Tons)

	New England	New York	Ontario	PJM	MISO	Total
2022	2,883	(796)	(1,130)	(513)	(39)	405
2023	2,760	(822)	(1,095)	(371)	(119)	352
2024	2,836	(1,061)	(998)	(797)	66	46
2025	2,853	(960)	(980)	(402)	54	566
2026	2,719	(833)	(895)	(892)	38	136
2027	2,766	(1,135)	(812)	(131)	(124)	563
2028	2,699	(1,130)	(812)	(356)	(149)	252
2029	2,847	(1,282)	(817)	(379)	(9)	360
2030	2,620	(1,172)	(775)	(580)	201	294
2031	2,251	(620)	(793)	(244)	(39)	555
10 Year Total	27,233	(9,812)	(9,107)	(4,665)	(120)	3,529

Figure 8 shows a comparison of the emissions impacts of NPT and the combined addition of GSPL and NRL for the entire modeled region, New England, and Massachusetts.

Figure 8: Total GHG Emission Impact, by Year



5. APPENDIX

5.1. New England Energy Modeling Assumptions

5.1.1. Retirements and New Capacity Additions

ESAI closely tracks retirements and new generation development on an ongoing basis. The modeled retirements and new generation additions provided below in Figure 9 and Figure 10 reflect ESAI's assumptions as of April 2017.

Figure 9: New England Modeled Retirements

Unit	Capacity, MW	Unit Type	Ret. Date		Status	Location
Jonesboro	27.5	Biomass	Mar	2016	Deactivated	ME
West Enfield	27.5	Biomass	Mar	2016	Deactivated	ME
Wheelabrator Claremont U5	3.6	MSW	Feb	2017	Deactivated	NH
Brayton Point (Units 1-4)	1,535	Coal	Jun	2017	Slated	SEMA
Brayton Point Diesels (Units 1-4)	10	Oil	Jun	2017	Slated	SEMA
Pilgrim	683	Nuclear	May	2019	Slated	SEMA
Front Street Diesels	8.25	Oil	Jun	2019	Slated	WMA
L Street Jet	16	Oil	Jun	2020	Slated	NEMA
Merrimack	439	Coal	Jun	2021	At-Risk	NH
Bridgeport Harbor	<u>400</u>	Coal	Jul	2021	Announced	CT
Total	3,150					

Figure 10: New England Modeled Generation Additions

Unit	Capacity, MW	Unit Type	Month	Year	Location
Jericho Mountain Wind	12	Wind	Jan	2016	NH
Northfield Mountain Uprate (Unit 1)	22	Hydro	Feb	2016	WMA
Wyman Uprate (Units 1 and 3)	7	Hydro	Mar	2016	ME
WED Coventry One	2	Wind	Jun	2016	RI
Passadumkeag Mountain	43	Wind	Jul	2016	ME
Tiverton Uprate	22	Nat gas	Nov	2016	RI
Hemphill Expansion	3	Biomass	Nov	2016	NH
Deepwater Wind	30	Wind	Nov	2016	RI
Bingham Wind (Blue Sky West)	185	Wind	Dec	2016	ME
Hancock Wind	51	Wind	Dec	2016	ME
Pisgah Mountain (Clifton Wind)	9	Wind	Dec	2016	ME
Footprint Power (Salem CC)	674	Nat gas	May	2017	NEMA
WED Coventry Six	5	Wind	May	2017	RI
MATEP	16	Oil	Jun	2017	NEMA
Berlin Station (Burgess) Expansion	7	Biomass	Jun	2017	NH
Lake Road Uprate	50	Nat gas	Jun	2017	CT
Orbit Energy HSAD Biogas	3	Biogas	July	2017	RI
Milford Power Uprate	33	Nat gas	Dec	2017	CT
Deerfield Wind	30	Wind	Dec	2017	VT
Medway Peaking	207	Nat gas	Apr	2018	SEMA
Southbridge Recycling and Disposal Park	1	Landfill Gas	May	2018	WMA
Wallingford Peaker Expansion	90	Nat gas	May	2018	CT
Towantic Energy Center	801	Nat gas	Jun	2018	CT
Bridgeport Harbor CC	509	Nat gas	Jun	2019	CT
Canal 3	342	Nat gas	Jun	2019	SEMA
Clear River Energy Center	485	Nat gas	Jun	2020	RI
Total	3,999				

5.1.2. Transmission Upgrades

ESAI tracks transmission development and models all viable transmission projects in New England as part of its energy modeling efforts. The following major projects have recently been completed and are included in ESAI's models:

- The Maine Power Reliability Program (MPRP) project increases transfer capacity across interfaces in Maine.
- The New England East West Solution upgrades (NEEWS) help alleviate congestion on the East-West interface and Connecticut Import Interfaces.
- The North Shore upgrades, which allow additional imports into NEMA.

5.2. Fuel Pricing

For this analysis, ESAI has utilized forward market gas prices as of June 27, 2017, shown in Figure 12.

Figure 11: Regional Gas Pricing Points

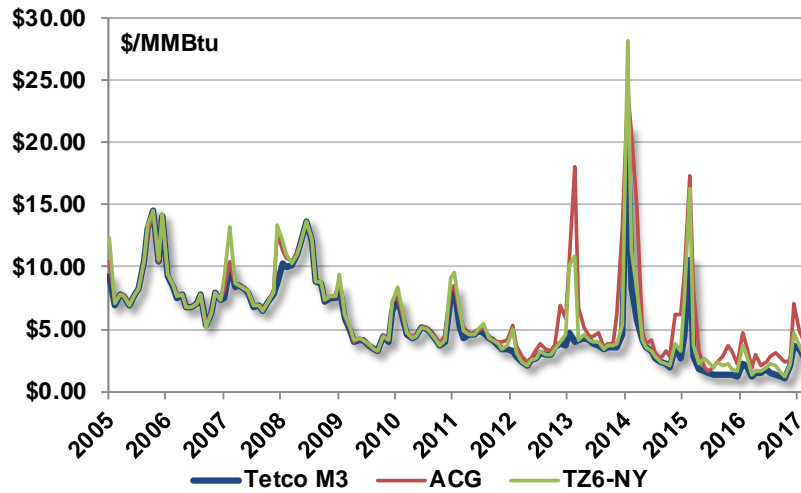
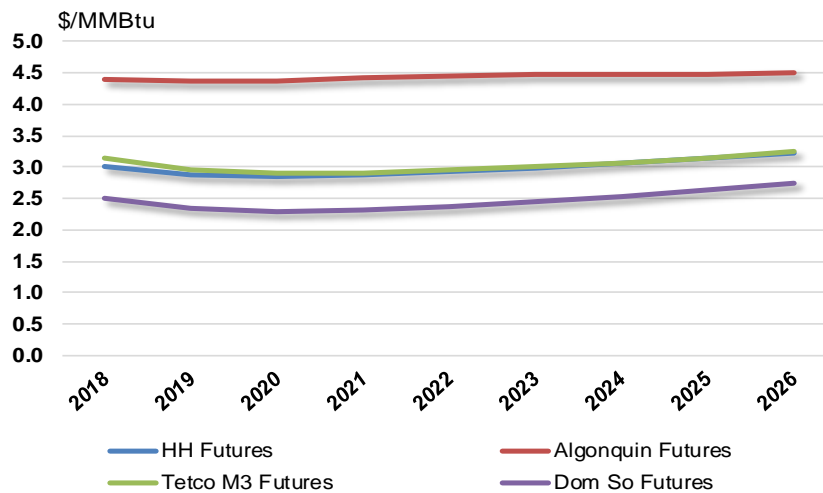


Figure 12: Fuel Price Assumptions



5.3. Demand

The ISO-NE long term forecasts for peak demand and energy utilized in the ESAI forecasts are shown in Figure 13 and Figure 14 and reflect the forecasts in the ISO-NE 2017 CELT forecast.

Figure 13: ISO-NE Zonal Peak Load Forecast

Summer Non-Coincident Peak Load By Zone, MW										
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Zonal Peak Load (50/50, Gross MW)										
CT	7,594	7,670	7,744	7,810	7,869	7,927	7,985	8,043	8,100	8,156
ME	2,196	2,215	2,235	2,254	2,270	2,288	2,306	2,326	2,345	2,365
MA	13,418	13,592	13,770	13,938	14,097	14,255	14,415	14,575	14,734	14,891
NH	2,630	2,669	2,709	2,748	2,786	2,824	2,863	2,901	2,940	2,978
RI	2,012	2,035	2,057	2,079	2,099	2,120	2,140	2,161	2,182	2,204
VT	1,117	1,128	1,138	1,147	1,156	1,165	1,174	1,183	1,192	1,201
Summer Coincident Peak Load (50/50, Gross MW)										
ISO-NE	28,966	29,307	29,652	29,975	30,276	30,578	30,883	31,190	31,493	31,794

Figure 14: ISO-NE Zonal Annual Energy Forecast

Control Area Annual Energy By Zone, GWh (Net PV & PDR)										
	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
CT	31,613	32,185	32,435	32,107	31,859	31,630	31,449	31,285	31,132	30,986
ME	11,585	11,595	11,668	11,716	11,644	11,591	11,558	11,538	11,525	11,521
MA	59,145	58,936	58,702	58,591	58,226	57,934	57,738	57,610	57,520	57,467
NH	11,710	11,786	11,867	11,942	11,982	12,026	12,078	12,134	12,190	12,244
RI	8,188	8,154	8,078	7,987	7,870	7,771	7,692	7,626	7,573	7,528
VT	5,775	5,783	5,848	5,916	5,825	5,741	5,667	5,596	5,530	5,466
ISO-NE	128,014	128,439	128,598	128,261	127,407	126,695	126,180	125,790	125,468	125,213

5.4. Environmental Regulations and Emission Allowance Prices

Figure 15 below provides ESAI's forecast of emission allowance prices used in this analysis.

Figure 15: ESAI Forecast of SO₂, NO_x, & CO₂ Emission Allowance Prices

ESAI FORECAST OF SO₂, NO_x, & CO₂ EMISSION ALLOWANCE PRICES				
(\$/short ton)	SO₂	Annual NO_x	Seasonal NO_x	RGGI CO₂
2017	5.00	6.50	625.00	2.25
2018	0.00	0.00	646.88	2.43
2019	0.00	0.00	669.52	2.62
2020	0.00	0.00	692.95	2.83
2021	0.00	0.00	717.20	3.06
2022	0.00	0.00	742.30	3.31
2023	0.00	0.00	768.28	3.57
2024	0.00	0.00	783.65	3.86
2025	0.00	0.00	799.32	4.16
2026	0.00	0.00	815.31	4.50

* RGGI CO₂ applies to ISO-NE, NYISO, MD & DE only.