STATE OF MAINE
OFFICE OF THE GOVERNOR
1 STATE HOUSE STATION
AUGUSTA, MAINE
04333-0001

JANET MILLS
GOVERNOR

DAN BURGESS
DIRECTOR
GOVERNOR'S ENERGY OFFICE

Dear Chairman Lawrence, Chairman Berry, and Members of the Committee on Energy, Utilities, and Technology:

Pursuant to Public Law 2019, Chapter 57 (LD 1401 *Resolve, To Study Transmission Solutions to Enable Renewable Energy Investment in the State*), the Governor's Energy Office convened a stakeholder group to address transmission system needs and funding strategies to support renewable energy investment in the State. LD 1401 directs the stakeholder group to, at a minimum, examine and make recommendations regarding:

1. Current constraints and barriers in the state and regional transmission system that impede planning for and realizing increased renewable energy development and integration in the State and the impact of these current system limitations on existing renewable energy resources, including the ability to qualify for the sale of energy and capacity in the regional wholesale energy markets. The stakeholder group shall make recommendations for improving the capability of the in-state transmission system to meet in-state demand and to export excess supply for the purposes of optimizing existing renewable energy resources and promoting in-state and regional system reliability;

2. Transmission infrastructure investment solutions and system improvements to realize different renewable energy development scenarios. The stakeholder group shall examine a minimum of 4 different renewable energy development scenarios that vary by total generation capacity, resource type and site location, taking into consideration the impact on siting and ratepayers and the relative benefits of different scenarios for energy consumers, transmission costs, existing generators, developers of new renewable energy resources and the environment;

3. Opportunities for regional coordination to advance transmission solutions to support new renewable energy resources capable of providing system reliability benefits to the State and the region, with consideration of publicly available data and studies available from ISO New England; and

4. Potential funding sources and strategies, including bonding and public-private partnerships, for renewable energy development.

The Governor's Energy Office was instructed to invite, at a minimum, a representative of: the Public Utilities Commission; the Office of the Public Advocate; ISO New England, Inc.; investor-owned transmission and distribution utilities; consumer-owned transmission and distribution utilities; a statewide renewable energy association; a statewide environmental organization; a statewide construction industry trade association; community-scale renewable energy resource generators; large industrial electricity consumers; and low-income electricity consumers. A full list of participants who engaged in this process can be found in the introduction of the report.

The stakeholder group met four times on the following dates: September 30, 2019; October 9, 2019; November 5, 2019; and November 21, 2019. There were stakeholders who participated both in-person

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and through a conference call line. The Governor's Energy Office established a webpage on the Energy Office website, which includes the schedule of meetings, meeting materials, and additional resources. The webpage can be found here: https://www.maine.gov/energy/governors-energy-office-stakeholder-group.html

This report reflects the discussions and feedback provided by this stakeholder group. It presents an explanation of the current transmission and distribution system, electricity market opportunities, current constraints, related studies, mechanisms for funding transmission upgrades, and options for further study. As the stakeholder process unfolded, it became clear that the scope of the report would need to be adjusted to reflect both time and resource limitations. In order to fully complete any modeling for the more thorough analysis, additional time and funding would be necessary. As a result, stakeholders agreed to narrow the scope of the analysis to those items mentioned above.

This report sets a foundation of understanding for future discussions of the challenges and possible avenues for solutions related to the transmission system and renewable energy investment in Maine. The Governor's Energy Office is available to answer any questions relating to process and provide connections to the experts in the stakeholder group for more specific technical questions, when appropriate.

Thank you to all the stakeholders for their participation and input throughout this process.

Sincerely,

Dan Burgess

Director
Governor's Energy Office
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PHONE: (207) 287-3531

Resolve, To Study Transmission Solutions To Enable Renewable Energy Investment in the State

Stakeholder Study Pursuant to Public Law 2019, Chapter 57

FINAL REPORT

January 3, 2020

INTRODUCTION

Pursuant to Public Law 2019, Chapter 57 (LD 1401 *Resolve, To Study Transmission Solutions to Enable Renewable Energy Investment in the State*) the Governor's Energy Office convened a stakeholder group to address transmission system needs and funding strategies to support renewable energy investment in the State. LD 1401 directs the stakeholder group to, at a minimum, examine and make recommendations regarding:

1. Current constraints and barriers in the state and regional transmission system that impede planning for and realizing increased renewable energy development and integration in the State and the impact of these current system limitations on existing renewable energy resources, including the ability to qualify for the sale of energy and capacity in the regional wholesale energy markets. The stakeholder group shall make recommendations for improving the capability of the in-state transmission system to meet in-state demand and to export excess supply for the purposes of optimizing existing renewable energy resources and promoting in-state and regional system reliability;
2. Transmission infrastructure investment solutions and system improvements to realize different renewable energy development scenarios. The stakeholder group shall examine a minimum of 4 different renewable energy development scenarios that vary by total generation capacity, resource type and site location, taking into consideration the impact on siting and ratepayers and the relative benefits of different scenarios for energy consumers, transmission costs, existing generators, developers of new renewable energy resources and the environment;
3. Opportunities for regional coordination to advance transmission solutions to support new renewable energy resources capable of providing system reliability benefits to the State and the region, with consideration of publicly available data and studies available from ISO New England; and
4. Potential funding sources and strategies, including bonding and public-private partnerships, for renewable energy development.

Participants who engaged in this stakeholder group:

- Denis Bergeron – Public Utilities Commission
- Benji Borowski – Preti Flaherty
- John Brodbeck – EDP Renewables
- Dwayne Conley – Northern Maine Independent System Administrator
- James Cote – Bernstein Shur
- Eliza Donoghue – Maine Audubon
- Skip Dumais – Van Buren Light & Power
- Bill Ferdinand – Eaton Peabody representing ISO-NE
- Todd Griset – Preti Flaherty
- Deb Hart – Dirigo Electric
- Barry Hobbins – Maine Public Advocate
- Eric Johnson – ISO-NE
- Paul Kohler – S.W. Cole Engineering Inc.
- Abigail Krich – Boreas Renewables
- Amy Kurt – EDP Renewables

- Matt Marks – Associated General Contractors
- Alan McBride – ISO-NE
- Tom Nason – E.S. Boulos Company
- David Norman – Emera Maine
- Lori Parham – AARP Maine
- Jeremy Payne – Maine Renewable Energy Association
- Tim Pease – Emera Maine
- Steve Perry – Sargent Corporation
- Francis Pullaro – RENEW-NE
- Alex Rost – ISO-NE
- Kerry Schlichting – ISO-NE
- Todd Shea – Kennebunk Light & Power District
- Greg Sherman – Houlton Water
- Arielle Silver Karsh – Emera Maine
- Eric Stinneford – Central Maine Power
- Paul Towle – Aroostook Partnership
- Dylan Voorhees – Natural Resources Council of Maine
- Rob Wood – The Nature Conservancy
- Angela Monroe – Governor's Energy Office/ Public Utilities Commission
- Dan Burgess – Governor's Energy Office
- Lisa Smith – Governor's Energy Office
- Melissa Winne – Governor's Energy Office

Stakeholders met on the following dates and participants joined either in-person or by phone:

- September 30, 2019
- October 9, 2019
- November 5, 2019
- November 21, 2019

Meeting materials are posted on the Governor's Energy Office website:
https://www.maine.gov/energy/governors-energy-office-stakeholder-group.html

As the stakeholder process unfolded, it became clear that the scope of the report would need to be adjusted to reflect both time and resource limitations. In order to fully complete the modeling required for the more thorough analysis outlined in statute, additional time and funding would be necessary. As a result, stakeholders agreed to narrow the scope of the analysis. This report provides an explanation of the transmission system, electricity market opportunities, current constraints, related studies, mechanisms for funding transmission upgrades, and options for further study. In addition, ISO New England is currently undertaking studies related to interconnection and the transmission system (described in greater detail later in this report) which, when completed, may provide valuable information to help inform discussions of potential solutions to the challenges presented in this study.

The charts in this report showing power flows across transmission interfaces in Maine were developed by the Public Utilities Commission using publicly available data from the ISO New England website.

RENEWABLE ENERGY GENERATION

Renewable energy generation can offer a variety of benefits for the State of Maine. Electricity generation from renewable resources have significantly less greenhouse gas emissions as compared to fossil fuel generation and do not require additional ongoing fuel costs for operation. Renewable energy development can also have a significant positive impact on the economy, creating a supply chain for installation, development, maintenance, and operation of renewable energy generation facilities. There are new legislative and regulatory initiatives that were recently enacted prioritizing renewable energy development.

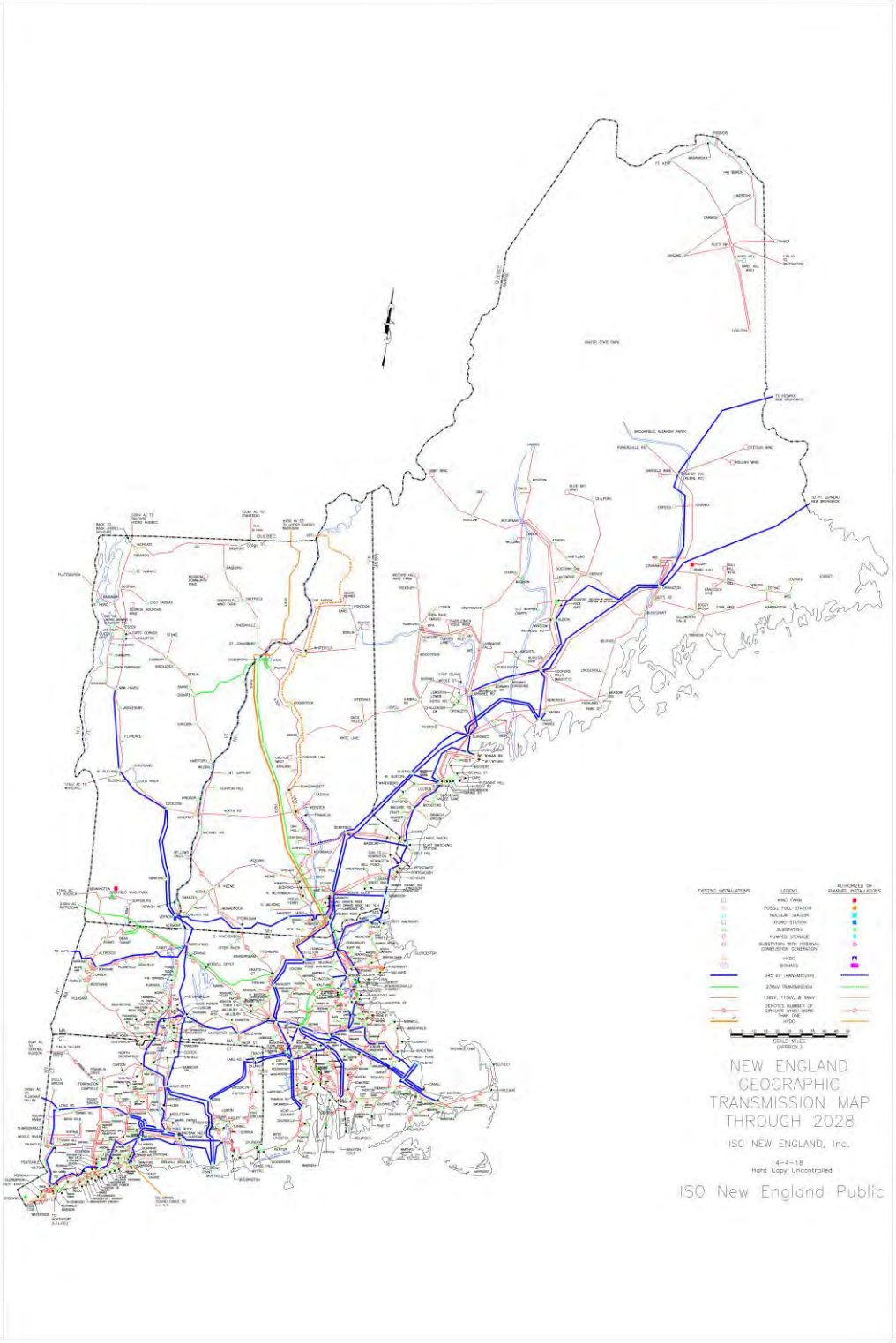
As a result of LD 1494: An Act To Reform Maine's Renewable Portfolio Standard, Maine now has one of the most ambitious Renewable Portfolio Standards (RPS) in the country. This legislation required a phased-in increase of Maine's RPS to 80 percent by 2030, up from 40 percent, and established a goal of 100 percent by 2050. This bill also requires Maine's Public Utilities Commission (PUC) to procure 14% of Maine load via 20-year long-term contracts. In addition, the bill creates a new Thermal Renewable Energy Certificate (TREC) of 4% to be phased in by 2030, beginning to establish a renewable energy certificate market for renewable heating. This legislation includes cost containment provisions, requires ongoing study, and creates the opportunity for additional grid-scale renewable energy generation both in Maine and regionally.

An additional piece of legislation, LD 1711: An Act To Promote Solar Energy Projects and Distributed Generation Resources in Maine, focused on incentivizing distributed generation up to 5 megawatts (MW). This legislation created a commercial and institutional net energy billing program, as well as a commercial and institutional and community-shared procurement for a total of 375 MW of distributed generation. Those programs are in addition to legislation that passed restoring net metering for residential customers.

MAINE'S ELECTRIC GRID

Maine's electricity grid is composed of transmission and distribution lines throughout the state. The transmission system is part of a New England regional grid that is operated by ISO New England (ISO-NE). Transmission lines are high-voltage lines that transport bulk electricity from power producers to the grid system over long distances. Electric utilities deliver electricity to residences, businesses, neighborhoods, and communities over shorter distances and lower voltages on distribution lines. While the transmission system is operated by ISO-NE, the electric utilities own the equipment at both the transmission and distribution level.

New England Geographic Transmission Map Through 2028



Source: ISO New England[1]

[1] ISO-NE. (n.d.) *Key Grid and Market Stats: Maps and Diagrams*. Retrieved from https://www.iso-ne.com/about/key-stats/maps-and-diagrams/#system-diagram

In 1997, the Maine Legislature enacted electric utility deregulation (PL 1997, c. 316). This legislation restructured the electric system, requiring investor-owned utilities to divest all generation assets and generation-related business activities, with a few exceptions, and opened the generation portion of electricity service to competition. The transmission and distribution of electricity remains regulated by the Public Utilities Commission. Maine's electric utility companies (listed in the chart below) are responsible for the line repair and maintenance, restoring service after storms and accidents, and providing customer services, including metering and billing. Consumers have the option to choose to buy their electricity from licensed competitive electricity providers (CEPs) or pay the standard offer rate, established by the Public Utilities Commission through a competitive bid process. The Maine Public Utilities Commission does not regulate the price of the electricity offered by CEPs.

Maine Electric Utilities (as of December 31, 2018)[2]

Investor-Owned Utilities	**Percent of State Residential Load**
Central Maine Power	78.9%
Emera Maine – Bangor Hydro District	13.6%
Emera Maine – Maine Public District	4.0%
Cooperatives & Municipal-Owned Utilities	
Eastern Maine Electric Cooperative	1.2%
Houlton Water Company	0.6%
Van Buren Light & Power District	0.2%
Kennebunk Light & Power	1.0%
Madison Electric Works	0.4%
Matinicus Plantation Electric Company	0.0%
Monhegan Plantation Power District	0.0%
Fox Island Electric	0.1%
Isle au Haut Electric Power Company	0.0%

While this report focuses primarily on the transmission system, the distribution system also plays an important role in the siting and interconnection of renewable energy generation. Some points of the distribution system face congestion and can influence the cost for projects to interconnect, as well as influence where certain projects are developed.

At the regional level, ISO-NE is the independent, not-for-profit company authorized by the Federal Energy Regulatory Commission (FERC) to perform three critical, complex, and interconnected roles for the region spanning Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, and most of Maine. According to ISO-NE, its three critical roles are: 1) grid operation (coordinating and directing the flow of electricity over the region's high-voltage transmission system); 2) market administration (designing, running, and overseeing the billion-dollar markets that attract a large and diverse mix of participants to buy and sell wholesale electricity at the most competitive prices); and 3) power system planning (conducting studies, analyses, and planning to make sure New England's electricity needs will be met over the next 10 years). ISO-NE strives to ensure that competitive markets are open to all

[2] Maine Public Utilities Commission. (2018). *Electricity Delivery Rates*. Retrieved from https://www.maine.gov/mpuc/electricity/delivery_rates.shtml

resources equally. ISO-NE is clear to note that it does not: handle retail electricity; own, maintain, or repair any of the power grid's infrastructure including power plants, power lines, and substations; enact or set energy policy; or have a financial stake in companies that own the infrastructure.[3]

When a generator wants to provide electricity to the grid, it must meet certain requirements to coordinate its operation with the electric utility to which it is interconnected, and the regional grid operator, ISO-NE. These requirements differ depending on the market in which they would like to participate. This report focuses primarily on the transmission system and constraints on this system. An explanation of the various markets will be followed by a discussion of current constraints, funding options for transmission upgrades, relevant studies, and opportunities for further study.

Northern Maine Transmission System

Northern Maine is different from the rest of the state and country in that it is not directly connected to one of the main power grids serving the United States – it is only connected via transmission lines that run through Canada. The Northern Maine Transmission System is administered by the Northern Maine Independent System Administrator (NMISA). NMISA is a non-profit entity responsible for the administration of the Northern Maine Transmission System and electric power markets in Aroostook and Washington counties. NMISA is responsible for providing an independent, objective and non-discriminatory administration of all transmission access, transmission information access, and related functions, and monitors and administers the markets in Northern Maine for energy, ancillary, and other services. NMISA administers the transmission system of the investor-owned and cooperatively-owned utilities in Northern Maine, and its members also include all municipally-owned utilities, generators, suppliers of energy, and large retail customers operating in the service area.[4]

ELECTRICITY MARKETS

Energy Markets (Day-Ahead and Real-Time Electricity Markets)

New England has two electric energy markets: the day-ahead market and the real-time energy market. The day-ahead market allows market participants to secure prices for electric energy the day before delivery and to hedge against price fluctuations that occur in real time. The real-time energy market balances the dispatch of generation and demand resources to meet the instantaneous demand for electricity throughout New England. Additionally, within the energy markets there are Financial Transmission Rights (FTRs) that a market participant can buy to hedge the price risk of day-ahead congestion caused by constraints on the transmission system. FTR holders have a right to receive, or an obligation to pay, the dollar amounts associated with congestion based on the amount of electric energy flowing between two specific locations.[5]

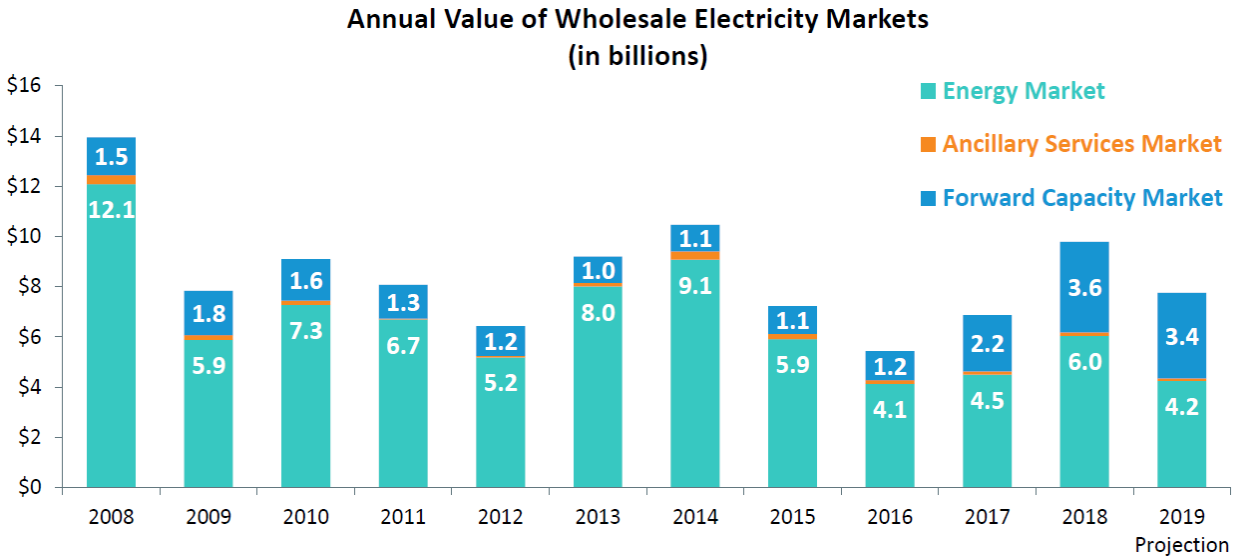
[3] ISO-NE. (n.d.). *Our Three Critical Roles*. Retrieved from https://www.iso-ne.com/about/what-we-do/three-roles
[4] Northern Maine Independent System Administrator. (n.d.). *Home.* Retrieved from https://www.nmisa.com/
[5] ISO-NE. (n.d.). *Administering the Wholesale Electricity Markets*. Retrieved from https://www.iso-ne.com/about/what-we-do/three-roles/administering-markets

Forward Capacity Market

The Forward Capacity Market (FCM) is the region's long-term capacity market, ensuring the system has sufficient electricity resources to meet the future demand. Generators are compensated by the market for committing to be available to meet the projected demand for electricity three years out and be available to operate when needed once the capacity commitment period begins. This commitment to supply power three years in advance is in exchange for a market-priced capacity payment. These capacity market payments can serve as a stable revenue stream for resources, particularly those that help meet peak demand but don't run often the rest of the year.[6]

Ancillary Markets

Ancillary markets provide services to power systems that are necessary for ensuring reliability in the short-term. The services within the ancillary market include regulation market, forward reserve market, real-time reserve pricing, voltage support, and blackstart capability. More information on these services can be found on ISO-NE's website. The ancillary market is a relatively small portion of the wholesale electricity markets and has several additional complexities. Because of this, and as directed by statute, this report will focus primarily on the energy and forward capacity markets.[7]



*2018 data are subject to adjustment and 2019 data are projected
Source: ISO-NE[8]

[6] ISO-NE. (n.d.). *Administering the Wholesale Electricity Markets*. Retrieved from https://www.iso-ne.com/about/what-we-do/three-roles/administering-markets
[7] ISO-NE. (n.d.). *Administering the Wholesale Electricity Markets*. Retrieved from https://www.iso-ne.com/about/what-we-do/three-roles/administering-markets
[8] ISO-NE. (December 2019). *ISO New England Update: Consumer Liaison Group Meeting*. Retrieved from https://www.iso-ne.com/static-assets/documents/2019/12/clg_meeting_george_iso_update_presentation_december_5_2019_final.pdf

According to ISO New England's Key Grid and Market Stats information, "While the energy-market value varies with fuel prices, the capacity market value varies with changes in amounts of supply competing to provide capacity (the FCM compensates resources for taking on an obligation to meet the region's electricity needs approximately three years after the annual auction is held). The capacity market value over the past two years was higher, reflecting a rash of generation retirements that led to a smaller amount of competing supply and thus higher prices. Strong competition has generally kept capacity market auction prices low for most years. However, as energy-market revenues decrease over time, prices in capacity and ancillary markets will likely rise to cover the costs for resources relying solely on market revenue (i.e., without state- and federal-based incentives) and are needed to balance renewable resources and provide energy security, particularly in the winter."[9]

Forward Capacity Auctions

Forward Capacity Auctions (FCAs) are held annually by ISO-NE to procure resources approximately three years in advance of when they will be needed. As was mentioned previously, there are certain requirements generators must meet to participate in the FCA. The Forward Capacity Market provides opportunities for both existing and new resources.

ISO-NE determines areas across its system that have different needs and limitations as relates to the regional transmission grid, called capacity zones. Capacity zones can be export-constrained, import-constrained, or contiguous (neither export nor import constrained). Starting in 2017, ISO-NE began using zonal demand curves to reflect the additional congestion price to be paid on top of the system capacity price for specific constrained capacity zones. More specifically, zonal demand curves for import-constrained zones specify a positive congestion price (or zero) to reflect that additional capacity in import-constrained zones may provide greater reliability value, whereas zonal demand curves for export-constrained zones specify a negative congestion price (or zero) to reflect that additional capacity in these zones may provide less reliability value.[10]

For FCA #14 to be held in 2020, within the export constrained Northern New England Zone (ME, NH, VT), Maine faces additional export constraints, creating what ISO-NE refers to as a nested export-constrained zone. Export-constrained zones are modeled when the maximum amount of resources that can be purchased in the zone, the maximum capacity limit, is less than the total of the existing and proposed new resources in the zone. Generation can still participate in the capacity market after the maximum capacity limit of an export constrained zone has been attained, but the ISO Sloped Demand Curve recognizes the reliability value of that generation is lower than the reliability value of generation outside the export constrained region, and it receives a relatively lower price. In such a situation, generators within the zone receive lower revenues, while the capacity costs to consumers is reduced relative to non-export-constrained zones. If a proposed generator is unable to participate in the capacity market, it may still go ahead with construction and participate in the energy market but would not receive capacity payments.

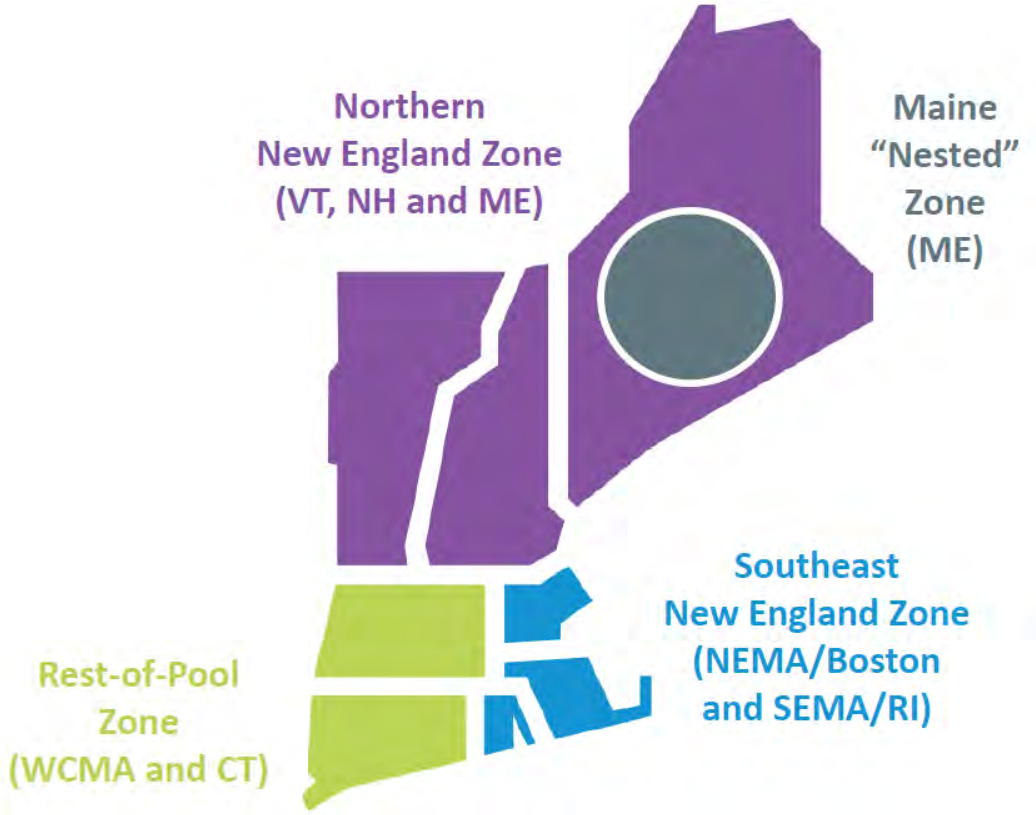
Volatility of prices in the real-time and day-ahead energy markets can make it economically challenging for some generators to maintain operation, particularly those that meet peak demand and don't

[9] ISO-NE. (n.d.) *About Us: Key Grid and Market Stats*. Retrieved from https://www.iso-ne.com/about/key-stats/
[10] ISO-NE. (n.d.). *About the FCM and Its Auctions*. Retrieved from https://www.iso-ne.com/markets-operations/markets/forward-capacity-market/fcm-participation-guide/about-the-fcm-and-its-auctions

operate for long periods of time. The additional revenue gained by participating in the capacity market may be necessary for these generators to be able to continue operating, and these generators can be necessary for the reliability of the grid.

ISO-NE studies the transmission system in the New England States and determines transmission capacity limits for certain areas. The limit is the total of all capacity resources in the area, modeled for operation of all generators operating simultaneously. Therefore, these capacity limits set by ISO-NE are not *necessarily* physical limitations on the infrastructure, but rather modeled constraints for participation in the capacity market. As a result of this capacity market construct, there are areas in Maine, which will be discussed in greater detail, where no new generation can currently qualify as a capacity resource due to capacity planning constraints.

ISO-NE Modeled Capacity Zones in FCA #14



Northern New England Zone	Export-Constrained
Maine "Nested" Zone	Nested Export-Constrained
Southeast New England Zone	Import-Constrained
Rest-of-Pool Zone	Neither Export Nor Import Constrained

Source: ISO-NE[11]

[11] ISO-NE. (December 2019). *ISO New England Update: Consumer Liaison Group Meeting.* Retrieved from https://www.iso-ne.com/static-assets/documents/2019/12/clg_meeting_george_iso_update_presentation_december_5_2019_final.pdf

CONSTRAINTS

An interface is a part of the transmission system where power flows may at times be restricted or "constrained." When an interface is constrained from an energy perspective, it means that not all the generation that is available and economic to run can actually operate. In this type of situation, the ISO-NE Operations Department will direct the least economic units to back down their generation to avoid exceeding the interface limits. Interfaces may be constrained from an energy market perspective and may also influence the ability for generators to participate in the capacity markets.

The difference between observed hourly flow rates and planning capacity limits of five different Maine interfaces can be seen in the charts by interface below (Charts 1, 3, 5, 7, 9). These charts demonstrate the frequency of hourly flows for the year, which often do not reach the modeled capacity limits ISO-NE determines for these interfaces. While new generators may not have the ability to participate in the capacity market in some areas due to transmission constraints, they may nevertheless be able to compete in the energy market, but may or may not experience significant congestion or curtailment. It is important to note, these charts do not show how often, or not, resources behind the interfaces may have been ordered offline to avoid exceeding limits. These charts are simply demonstrating what current flow rates are at these interfaces in relation to planning capacity limits.

The additional charts (Charts 2, 4, 6, 8, 10) show the flow rates across these interfaces as compared to raw hourly operating limits. Actual operating limits may be reduced to account for any outages or limitations that result from particular generators dispatched to operate in real-time. This demonstrates that, particularly at the Orrington-South interface, there is significant transmission congestion in real time operations.

While this data shows a snapshot of the transmission grid system, the grid itself is variable and can change significantly from year to year. The data presented in these charts illustrates a complex picture and demonstrates, in a simplified way, how the grid functioned during 2018.

Interfaces & Locations

There are several transmission and distribution areas throughout Maine that face, or may face, constraints for exporting electricity that were identified by the stakeholder group.

<u>Orrington-South</u>

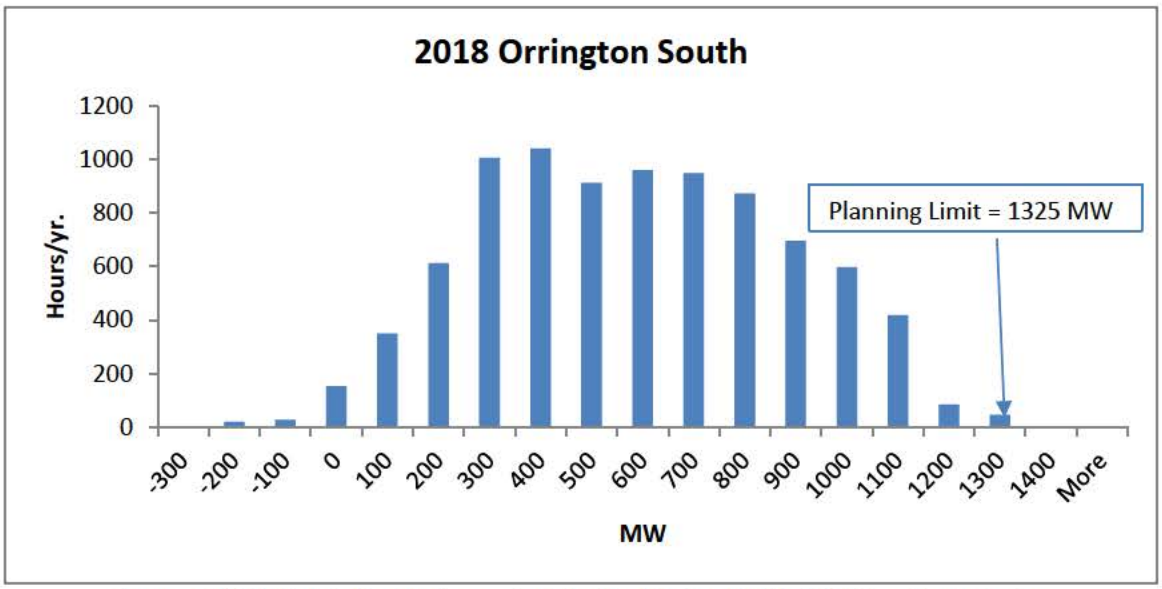
The Orrington-South interface impacts Maine's transmission system. For capacity modeling, the area is significantly export constrained, meaning there are limitations on the amount of additional generation above the Orrington substation that can participate on the forward capacity market. Currently, no new generation above the Orrington-South interface can qualify as a capacity resource.

Generation above Orrington-South can participate in the ISO-NE energy markets, whether or not it participates in the capacity market, though congestion and hourly operating limits can impact the amount of generation capable of participating in the energy market as well. Chart 1 shows the hourly flows in 2018 through Orrington-South as compared to the planning capacity limit which is modeled at 1325 MW. This demonstrates that hourly flows do not often reach the planning capacity limit. However, flows that are less than the planning limit do not necessarily mean that greater levels of supply are not available. ISO-NE may direct generators to stop generating, also known as curtailment, in order to

manage transmission congestion. Chart 2 shows the hourly flow rates as compared to hourly operating limits, illustrating that overall, generation is often congested and limited at this interface.

If transmission upgrades were made to this interface, additional generation, and potentially current generation participating in energy markets only, may have the ability to participate in the capacity market; however, additional generation flowing through Orrington-South may also create congestion on the transmission grid further south. The upgrades may also have economic impacts on the price paid for generation on the ISO-NE energy markets. Additional study and modeling would be needed to fully understand this impact. At RENEW's request, ISO-NE is currently studying the economic impact of conceptual increases in hourly operating limits on the Orrington-South interface from conceptual transmission upgrades, with a report expected in early 2020.

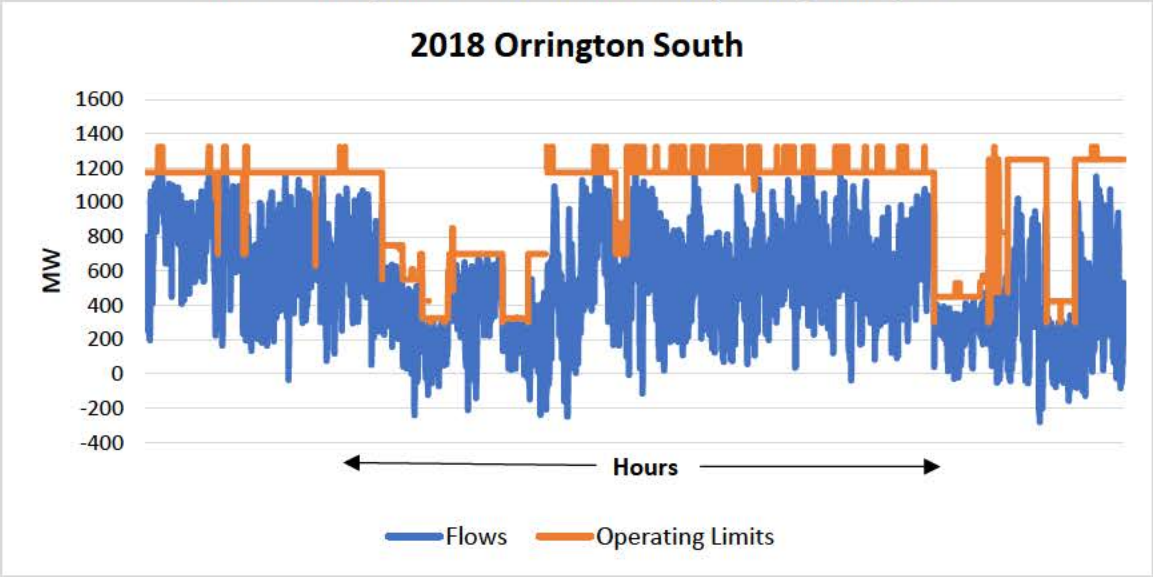
Chart 1 – Orrington-South Hourly Flow Rates and Capacity Limits, 2018



Source: ISO-NE data[12], charts created by the Maine Public Utilities Commission

[12] ISO-NE. (February 2019). *Energy, Load, and Demand Reports: Historical Hourly Flow and Limits*. Retrieved from https://www.iso-ne.com/isoexpress/web/reports/load-and-demand/-/tree/historical-hourly-flows-and-limits

Chart 2 – Orrington-South Flow Rates and Operating Limits, 2018



Source: ISO-NE data[13], charts created by the Maine Public Utilities Commission

Northern Maine

The binding capacity constraint for Northern Maine has led to proposals to deliver electricity from Northern Maine, bypass Orrington-South and go straight to load-centers in Maine or even bypass the Maine grid altogether and serve load in Southern New England. This would not necessarily connect the Northern Maine Grid to ISO-NE, but could rather provide a long generator lead line to deliver electricity directly to load in Maine or in Southern New England, avoiding current limitations for generators in Northern Maine from participating in capacity markets. There are also proposals to connect the Northern Maine grid directly to ISO-NE. In-depth analysis would be needed to understand the impacts of that connection.

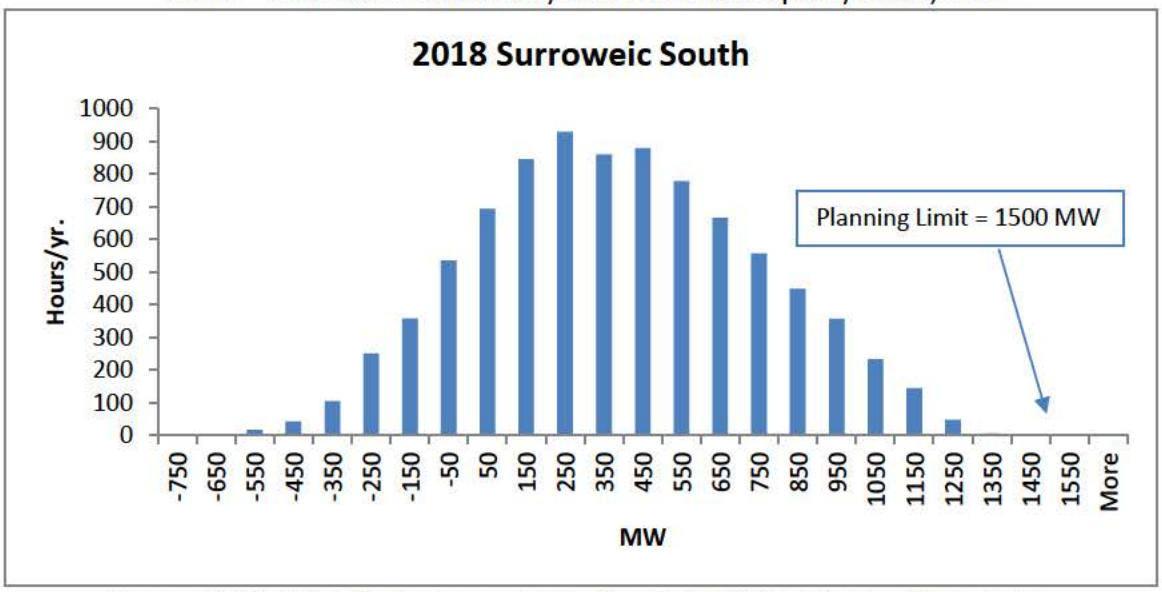
Pursuant to Maine Public Law 2019, Chapter 71 (LD 1796), the Governor's Energy Office has been directed to convene a stakeholder group to identify and develop strategies to address the transmission grid reliability and electric rate stability for the northern Maine service territory. The report will further discuss reliability and renewable energy generation issues on the grid system in Northern Maine.

Suroweic-South

Suroweic-South interface is not currently capacity constrained, as it has some headroom (room for additional generation) available. Chart 3 shows the flow rates as compared to the planning capacity limit of 1500 MW, illustrating that generation does not currently meet the modeled capacity limit. Chart 4 shows that flow rates are not often constrained by operating limits. Depending on the amount of headroom available, and the location and amounts of generation coming online, this interface is likely to become congested with significant future additions of imports or renewable energy development.

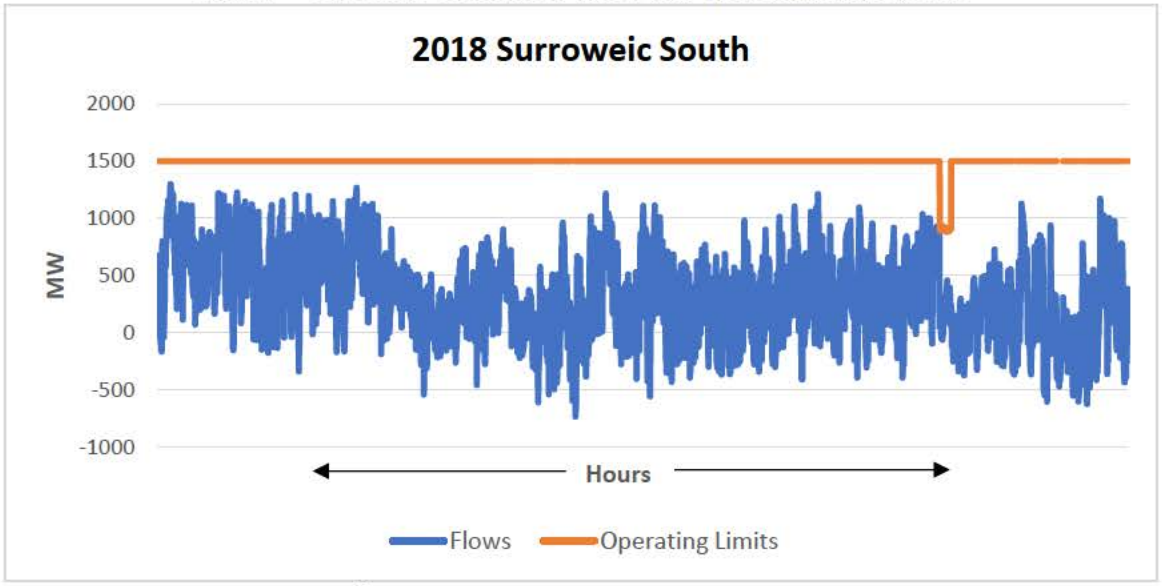
[13] ISO-NE. (February 2019). *Energy, Load, and Demand Reports: Historical Hourly Flow and Limits*. Retrieved from https://www.iso-ne.com/isoexpress/web/reports/load-and-demand/-/tree/historical-hourly-flows-and-limits

Chart 3 – Surroweic-South Hourly Flow Rates and Capacity Limits, 2018



Source: ISO-NE data[14], charts created by the Maine Public Utilities Commission

Chart 4 – Surroweic-South Flow Rates and Operating Limits, 2018



Source: ISO-NE data[15], charts created by the Maine Public Utilities Commission

[14] ISO-NE. (February 2019). *Energy, Load, and Demand Reports: Historical Hourly Flow and Limits*. Retrieved from https://www.iso-ne.com/isoexpress/web/reports/load-and-demand/-/tree/historical-hourly-flows-and-limits

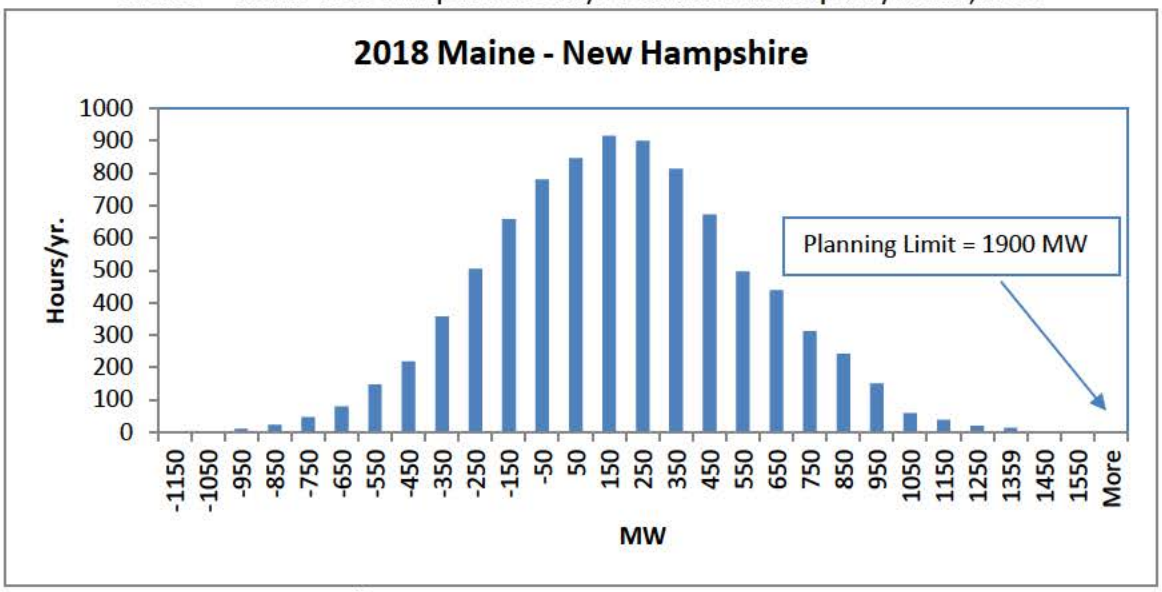
[15] ISO-NE. (February 2019). *Energy, Load, and Demand Reports: Historical Hourly Flow and Limits*. Retrieved from https://www.iso-ne.com/isoexpress/web/reports/load-and-demand/-/tree/historical-hourly-flows-and-limits

Maine/New Hampshire Interface

Currently the Maine/New Hampshire Interface is not largely constrained. However, with additional amounts of potential future development, including at the distribution level, and any expansion of use of the upstream interfaces to the north, this constraint may become binding more often. Chart 5 shows the flow rates as compared to the modeled capacity limit. Chart 6 shows the flow rates as compared to operating limits, which shows some headroom available through this interface.

New generation does not need to flow through this interface in order to qualify for capacity market participation. However, overall, Maine is an export-constrained zone for the FCM and that can influence the price paid for capacity located within the State. If Maine becomes more export constrained, there could be additional price impacts. Additionally, as with some of the other identified interfaces, as more electricity is generated in Maine, including at the distributed energy level, this constraint could become more binding.

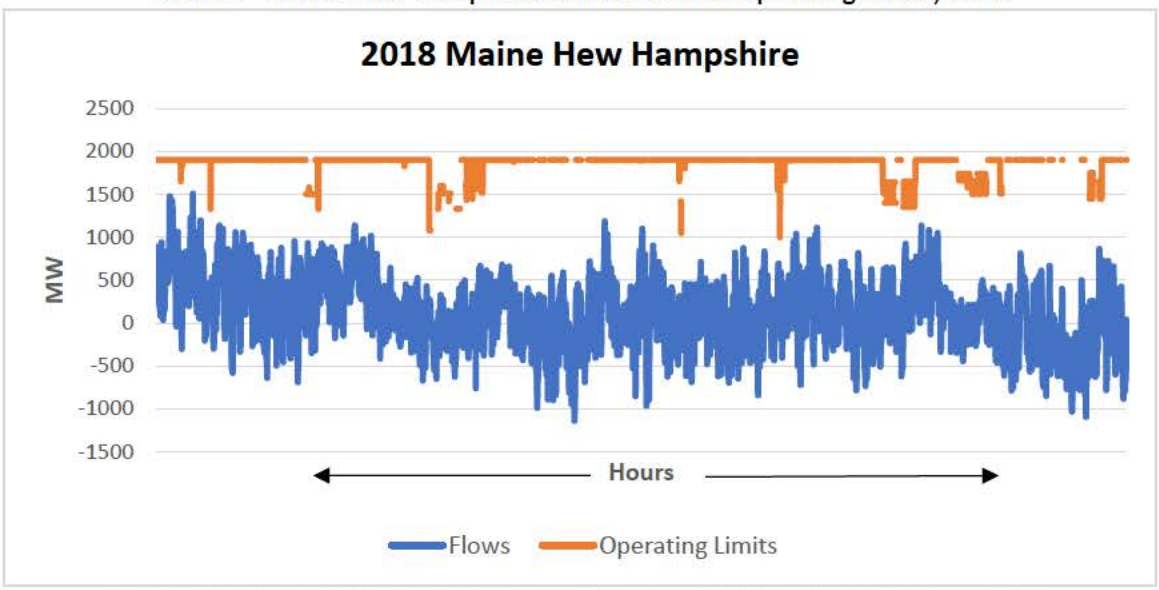
Chart 5 – Maine-New Hampshire Hourly Flow Rates and Capacity Limits, 2018



Source: ISO-NE data[16], charts created by the Maine Public Utilities Commission

[16] ISO-NE. (February 2019). *Energy, Load, and Demand Reports: Historical Hourly Flow and Limits*. Retrieved from https://www.iso-ne.com/isoexpress/web/reports/load-and-demand/-/tree/historical-hourly-flows-and-limits

Chart 6 – Maine-New Hampshire Flow Rates and Operating Limits, 2018



Source: ISO-NE data[17], charts created by the Maine Public Utilities Commission

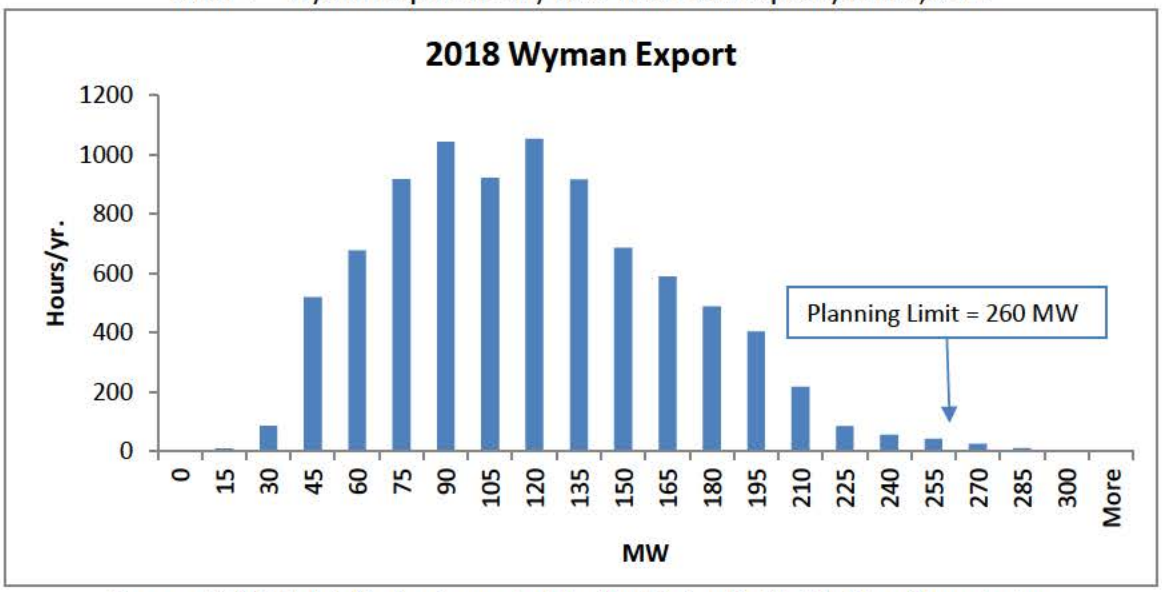
Local Constraints

With recent legislation providing the structure for significant growth in distributed generation, there is the potential for this generation to create additional transmission constraints. The location and amounts of distributed generation will determine the full-scale impact.

There are a number of areas where local transmission constraints could affect renewable energy development. Two examples of where local transmission constraints exist are Wyman Export and Keene Road Export. Chart 7 shows flow rates as compared to the planning capacity limit for Wyman-Export interface, indicating the area to be an exporting area, which therefore has the potential for more binding constraints moving forward. Chart 8 shows the flow rates as compared to operating limits, demonstrating some congestion. Chart 9 shows the flow rates compared to the planning capacity limit for Keene Road Export, illustrating that generation levels can be high compared with export limits. Finally, Chart 10 shows flow rates as compared to operating limits for Keene Road, further demonstrating the binding congestion often experienced at this interface. Keene Road is also located north of the Orrington-South interface. These two areas are not all encompassing of local constraints impacting the opportunity for renewable energy generation in Maine, but are two examples of where local constraints may be limiting.

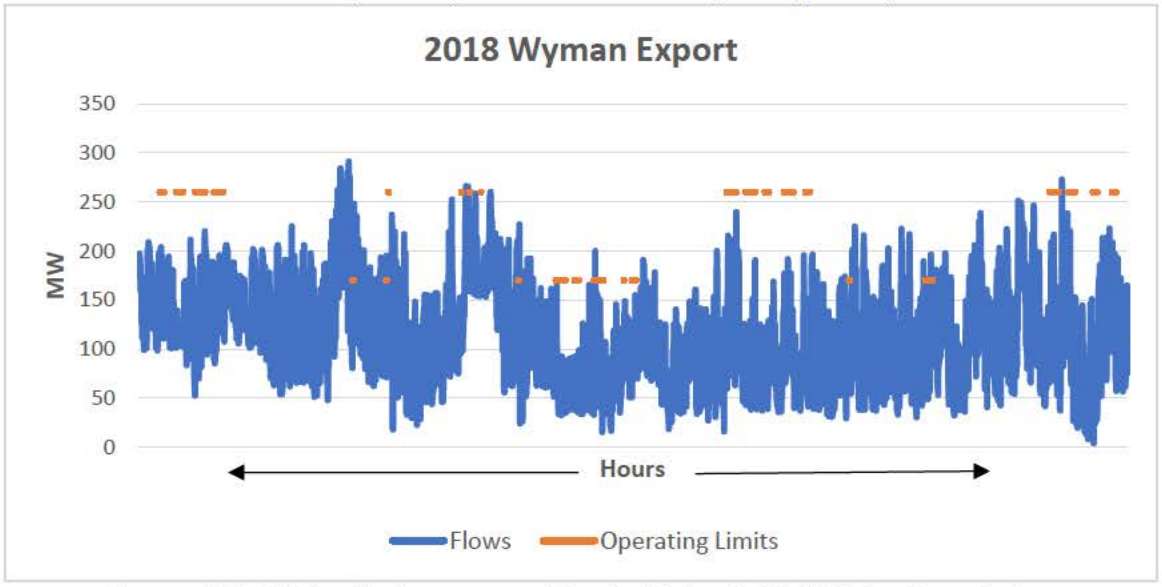
[17] ISO-NE. (February 2019). *Energy, Load, and Demand Reports: Historical Hourly Flow and Limits*. Retrieved from https://www.iso-ne.com/isoexpress/web/reports/load-and-demand/-/tree/historical-hourly-flows-and-limits

Chart 7 – Wyman Export Hourly Flow Rates and Capacity Limits, 2018



Source: ISO-NE data[18], charts created by the Maine Public Utilities Commission

Chart 8 – Wyman Export Flow Rates and Operating Limits, 2018

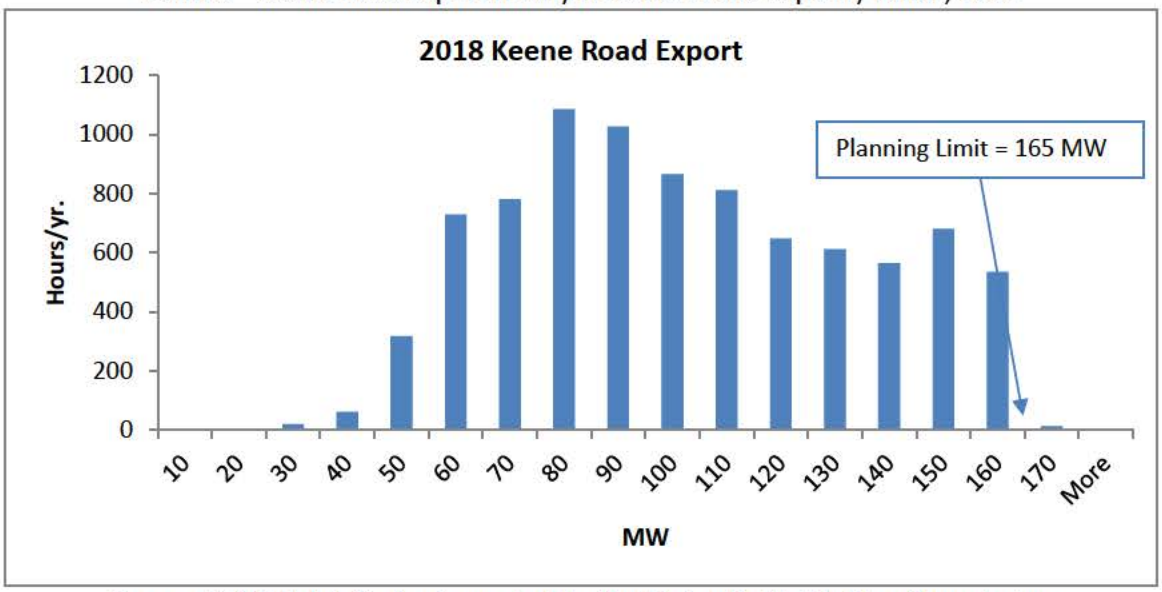


Source: ISO-NE data[19], charts created by the Maine Public Utilities Commission

[18] ISO-NE. (February 2019). *Energy, Load, and Demand Reports: Historical Hourly Flow and Limits*. Retrieved from https://www.iso-ne.com/isoexpress/web/reports/load-and-demand/-/tree/historical-hourly-flows-and-limits

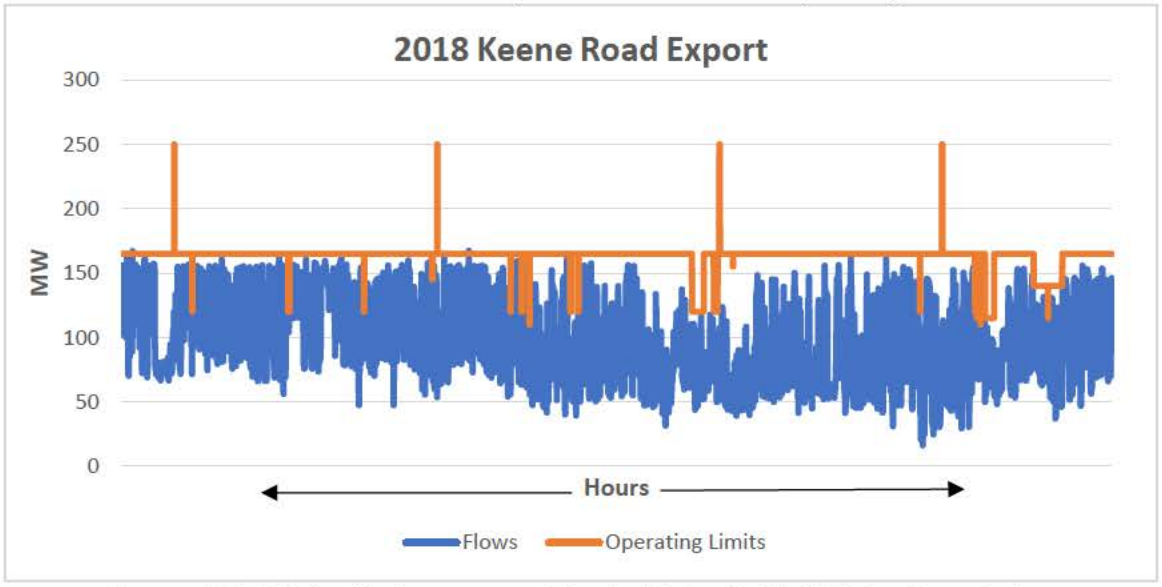
[19] ISO-NE. (February 2019). *Energy, Load, and Demand Reports: Historical Hourly Flow and Limits*. Retrieved from https://www.iso-ne.com/isoexpress/web/reports/load-and-demand/-/tree/historical-hourly-flows-and-limits

Chart 9 – Keene Road Export Hourly Flow Rates and Capacity Limits, 2018



Source: ISO-NE data[20], charts created by the Maine Public Utilities Commission

Chart 10 – Maine-New Hampshire Flow Rates and Operating Limits



Source: ISO-NE data[21], charts created by the Maine Public Utilities Commission

[20] ISO-NE. (February 2019). *Energy, Load, and Demand Reports: Historical Hourly Flow and Limits*. Retrieved from https://www.iso-ne.com/isoexpress/web/reports/load-and-demand/-/tree/historical-hourly-flows-and-limits

[21] ISO-NE. (February 2019). *Energy, Load, and Demand Reports: Historical Hourly Flow and Limits*. Retrieved from https://www.iso-ne.com/isoexpress/web/reports/load-and-demand/-/tree/historical-hourly-flows-and-limits

ADDITIONAL FACTORS POTENTIALLY AFFECTING EXISITING AND FUTURE CONSTRAINTS

Demand in Maine

The Mills Administration has set goals and actions in place to begin diversifying transportation and heating sector fuels, in part by increasing electricity as a fuel source. The impact of these goals and actions may be an increased electric load statewide, although the timing and degree of that impact, as well as the counter-impact of energy efficiency investments, are not yet known. New demand could also come at times of the day when demand is already high, potentially increasing the need for some combination of additional generation, transmission and distribution, or non-wires alternatives such as energy storage or demand response. Alternatively, the increased local demand may help relieve stability driven constraints in certain areas, as the generation could be used locally for heating and charging vehicles.

ISO-NE has begun the process of incorporating increased demand from heat pumps and transportation as part of their CELT (Capacity, Energy, Loads, and Transmission) forecasting tool. The 10-year projections provided in the CELT Report are used by ISO-NE in power system planning and reliability studies. This analysis goes through the ISO-NE's Load Forecast Committee, and Maine is participating in these conversations. This analysis from ISO-NE could be a valuable tool for further analyzing the potential impact of beginning to electrify the heating and transportation sectors in the State, as well as the impact on the regional grid. The Maine Climate Council is also considering these issues and will release a Climate Action Plan in December 2020.

Offshore Wind Development

Offshore wind development in Maine and across the region could potentially provide significant amounts of generation onto the New England grid. At this time, offshore wind projects have not been proposed for Maine beyond the Maine Aqua Ventus demonstration project in state waters. Maine is participating in the federally-led Bureau of Ocean Energy Management Gulf of Maine Intergovernmental Renewable Energy Task Force to identify potential lease areas for offshore renewable energy development in federal waters. Until specific areas or projects have been identified, it is difficult to understand the potential impact of offshore wind development on Maine's current transmission system. Further study would be needed to fully understand the potential impacts. At NESCOE's request, ISO-NE is currently conducting an economic study of the impact of offshore wind on the southeastern New England electric grid.

Storage

Advanced energy storage could play a key role in Maine and New England's electricity sector and in helping meet our collective energy challenges. Storage can increase affordability and resiliency and could also offer greater flexibility in managing the grid and integrating renewable energy. The impact of energy storage is predicated on the amount of storage, how it is dispatched, and where it is located. Both the distributed generation (LD 1711 *An Act To Promote Solar Energy Projects and Distributed Generation Resources in Maine)* and RPS (LD 1494 *An Act To Reform Maine's Renewable Portfolio Standard)* legislation described in the "Renewable Energy Generation" section of this report have provisions that allow for energy storage to pair with generation, creating a potential opportunity for additional storage in Maine. Furthermore, the increase of electric vehicles in Maine could provide a

potential opportunity for batteries in vehicles to act as storage devices on the grid. Modeling and quantifying the impacts of energy storage on existing and future transmission constraints would require additional time and financial resources.

Pursuant to Maine Law 2019, Chapter 83 (LD 1614) a Legislative Commission was established to study the economic, environmental and energy benefits of energy storage to the Maine electricity industry. In January 2020 this Commission submitted their report which includes its findings and recommendations regarding energy storage for Maine. This may help to inform ways Maine can pursue energy storage solutions moving forward.

Non-wires Alternatives

In some instances, there may be opportunities to pursue nonwires alternatives rather than building new transmission infrastructure. According to Maine Law 2019, Chapter 298, a nonwires alternative means "a nontransmission alternative or an infrastructure, technology or application that defers or reduces the need for capital investment in the transmission and distribution system and addresses system reliability needs proposed to be met by the transmission or distribution system investment." Recent legislation (LD 1181 *An Act To Reduce Electricity Costs through Nonwires Alternatives*) created the position of Nonwires Alternative Coordinator under the Office of the Public Advocate who will be reviewing certain proposals for transmission upgrades and providing an analysis of nonwires alternatives that may be pursued in place of the transmission upgrade. As this moves forward, there may be greater opportunities for nonwires alternatives to transmission upgrades brought to light in Maine.

OVERVIEW OF CURRENT STUDIES

There are a number of studies that are currently underway or recently completed that relate to the topics outlined in this report.

ISO-NE: NESCOE (Offshore Wind)

The purpose of this ISO-NE study, requested by NESCOE (New England States Committee on Electricity), is to study the impacts on transmission system and wholesale market of increasing penetration of off-shore wind resources. The transmission analysis includes: high-level conceptual transmission overlays; transmission upgrade cost estimates; and various points of interconnection. The request is to analyze integrated new wind resources at different points of interconnection into New England and estimate transmission upgrade costs associated with these conceptual configurations. The wholesale market impacts to be studied include: energy, capacity, and ancillary services; prices and air emissions; and ancillary service requirements.[22]

ISO-NE: RENEW (Orrington-South Constraint)

The purpose of this ISO-NE study, requested by RENEW, is to study the economic impact of conceptual increases in hourly operating limits on the Orrington-South interface from conceptual transmission upgrades. The RENEW scenarios will model varying degrees of increases in Orrington-South. The transmission system will be modeled using 2025 internal interface transfer capabilities, with the

[22] ISO-NE. (May 21, 2019) *2019 Economic Studies: Draft Scope of Work and High-Level Assumptions*. Presentation.

exception of the Orrington-South interface. The base scenario will assume modified 2016 raw operating limits, as provided by RENEW. In scenario 1, the increase in operating limits requested by RENEW ranges from 0 to 170 MW from the assumed modified 2016 raw operating limits. In scenario 2, the increase in operating limits requested by RENEW ranges from 100 to 825 MW from the assumed modified 2016 raw operating limits. The analysis will be performed in two ways, with and without the interfaces downstream of Orrington-South being modeled at the limits projected for 2025.[23]

ISO-NE: 2016/2017 Maine Resource Integration Study

Executive Summary: ISO New England (ISO) conducted the *2016/2017 Maine Resource Integration Study* (MRIS) to identify the transmission upgrades necessary to enable the interconnection of proposed new resources in northern and western Maine. The study was conducted in parallel with the development of an approach to clustering Interconnection Requests in the ISO-administered interconnection queue, which was approved by the Federal Energy Regulatory Commission (FERC) in an October 31, 2017 order. The clustering approach reflected in the FERC-approved rules uses a two-phased study methodology in certain circumstances to expedite the consideration of two or more Interconnection Requests and allocate interconnection upgrade costs among Interconnection Customers (ICs) on a cluster basis.[24]

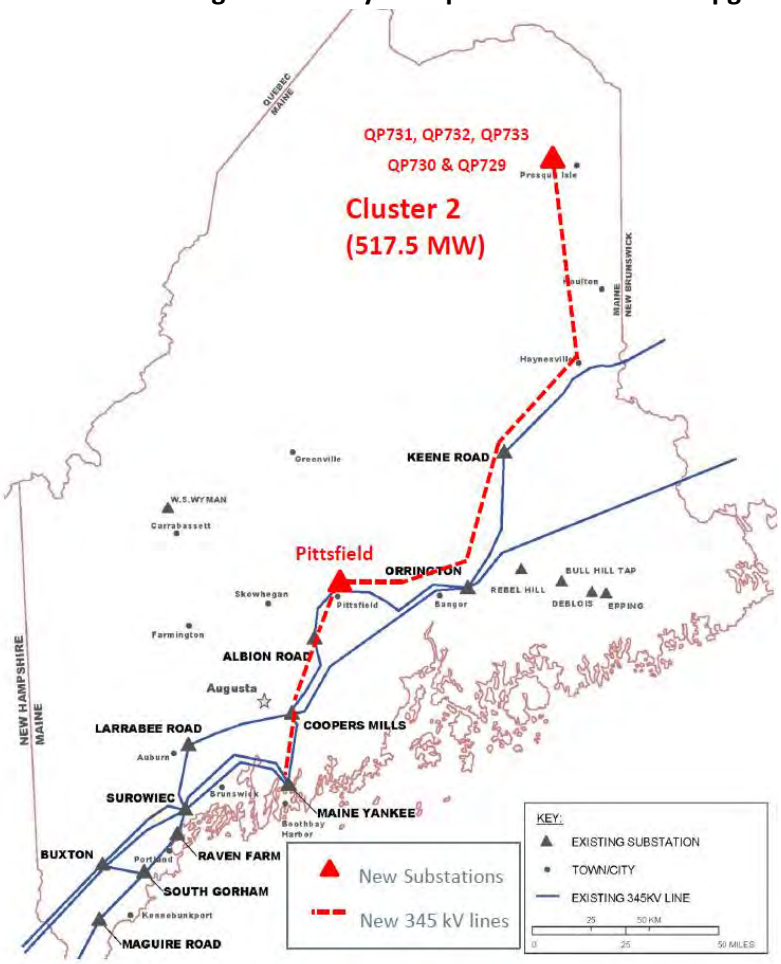
ISO-NE: Second Maine Resource Integration Study

The scope of the second Maine Resource Integration Study is to identify potential transmission infrastructure that could be needed to interconnect queued generation in Maine. In the June 17, 2019 Planning Advisory Committee (PAC) meeting the ISO presented preliminary results of the Second MRIS. The results identified that, for a HVDC connection from the Maine system to southern New England: additional upgrades are required for connections that are further north in Maine or in New Brunswick; and the continency loss of the HVDC connection itself results in the need for dynamic reactive upgrades to maintain the voltage and stability of the system. Since the initiation and scoping of the Second MRIS, several projects in Northern and Western Maine have withdrawn from the interconnection queue. Currently, only 520 MW of incremental generation remains cluster-eligible for the Second MRIS. As a result of PAC discussions, the initial use of HVDC connections was abandoned and the exploration of Cluster-Enabling Transmission Upgrades (CETUs) reverted back to concepts that had been developed in the first MRIS.[25]

The proposed transmission upgrades are shown in the map below. These proposed upgrades include: two new 345 kV substations (Pittsfield and Number Nine); one new 345 kV line from Pittsfield to Number Nine; one new 345 kV line from Pittsfield to Coopers Mills; one dynamic reactive device; and two new reactors, one at Pittsfield and one at Number Nine.[26] This report is still in drafting phase, with a final report expected in January 2020.

[23] ISO-NE. (May 21, 2019) *2019 Economic Studies: Draft Scope of Work and High-Level Assumptions*. Presentation.
[24] ISO-NE. (March 2018). *2016/2017 Maine Resource Integration Study*. Report.
[25] ISO-NE Presentation to the Planning Advisory Committee (PAC). (November 20, 2019). *Second Maine Resource Integration Study: Results*
[26] ISO-NE Presentation to the Planning Advisory Committee (PAC). (November 20, 2019). *Second Maine Resource Integration Study: Results*

Second Maine Resource Integration Study – Proposed Transmission Upgrades



Source: ISO-NE[27]

FUNDING MECHANISMS AVAILABLE FOR TRANSMISSION UPGRADES

Within the FERC tariff for ISO-NE, there are various avenues provided to finance transmission system upgrades. An overview of these options is provided below:

1. Market Efficiency Transmission Upgrades (METU) are upgrades designed primarily to provide a net reduction in total production cost to supply the system load. These upgrades are identified by ISO New England where the reduction in production costs to supply system load exceeds the cost of the transmission upgrade.[28] METU costs are shared among all six New England states in proportion to their share of the regional load. In the history of ISO-NE, no METU has ever been identified.

[27] ISO-NE Presentation to the Planning Advisory Committee (PAC). (November 20, 2019). *Second Maine Resource Integration Study: Results*

[28] ISO-NE. (n.d.) *Market Efficiency Transmission Upgrades.* Retrieved from https://www.iso-ne.com/system-planning/system-plans-studies/metu

2. Public Policy Transmission Upgrades (PPTU) are improvements of or additions to the regional transmission system designed to meet state, federal, and local (municipal and county) public policy requirements as driving transmission needs.[29] To date, no public policies have been identified that would trigger the need for a PPTU.

3. Network Upgrades are additions, modifications, and upgrades to the New England Transmission System required at or beyond the Point of Interconnection to accommodate the interconnection of an Interconnection Customer to the Administered Transmission System. They are funded entirely by the interconnection customer, either individually if the interconnection is studied serially, or as a group if studied as a cluster.[30]

4. Cluster-Enabling Transmission Upgrade (CETU) is a new significant transmission line infrastructure that consists of AC transmission lines and related terminal equipment having a nominal voltage rating at or above 115 kV or HVDC transmission lines and HVDC terminal equipment that is identified through the Clustering Enabling Transmission Upgrade Regional Planning Study conducted to accommodate the CETU shall be considered part of an ETU Interconnection Related Upgrade and be categorized as Interconnection Facilities or Network Upgrades.[31] CETUs would be funded by interconnection customers.

5. Reliability Transmission Upgrade (RTU) is identified through needs assessments regularly performed by ISO-NE to study the adequacy of the region's networked transmission facilities to maintain reliability and promote the operation of efficient wholesale electricity markets in New England. If a need is expected to be required in more than three years' time, ISO-NE solicits competitive solutions through a request for proposals (RFP) process. If the need is expected to be required in less than three years, a solutions study is performed by ISO-NE to identify the most cost-effective way to meet the need.[32] Reliability upgrade costs are shared among all six New England states in proportion to their share of the regional load.

6. Elective Transmission Upgrades (ETU) can be undertaken by either a utility or a private entity. That entity would be required to undertake the design, construction, and interconnection of an ETU, requiring compliance with ISO-NE procedures and studies. Any entity that constructs and/or maintains the ETU shall be responsible for 100% of the costs of said upgrade. A request for rate treatment of an ETU, if any, shall be determined by the Commission in the appropriate proceeding.[33]

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[29] ISO-NE. (n.d.) *Public Policy Transmission Upgrades.* Retrieved from https://www.iso-ne.com/system-planning/system-plans-studies/public-policy-transmission-upgrades

[30] ISO-NE. (January 2019). *Schedule 22 Large Generator Interconnection Procedures*. Retrieved from https://www.iso-ne.com/static-assets/documents/regulatory/tariff/sect_2/sch22/sch_22_lgip.pdf

[31] ISO-NE. (January 2019). *Schedule 25 Elective Transmission Upgrade Interconnection Procedures.* Retrieved from https://www.iso-ne.com/static-assets/documents/2015/02/sch_25.pdf

[32] ISO-NE. (n.d.) *About Competitive Transmission Projects in New England*. Retrieved from https://www.iso-ne.com/system-planning/transmission-planning/competitive-transmission-projects/about-competitive-transmission-projects

[33] Section II ISO New England Open Access Transmission Tariff. Retrieved from https://www.iso-ne.com/static-assets/documents/regulatory/tariff/sect_2/oatt/sect_ii.pdf

In addition to these options for direct transmission upgrades, regional procurement of renewable energy could provide an avenue for the collaborative buying and selling of power, including transmission upgrades. A regional procurement could establish the market opportunity to spur renewable energy generation and the development of transmission upgrades, sharing the costs among state participants.

One example of regional renewable energy procurement efforts in New England is the New England Three-State Clean Energy RFP between Massachusetts, Connecticut, and Rhode Island. Each state was able to create their own statutory framework for the procurement and the state entities responsible for soliciting proposals worked together to release a joint RFP in September of 2015. Once proposals were in, the states collectively selected projects to meet their respective statutory framework.[34] Future opportunities may be available for regional collaboration resulting in cost-sharing between states.

Additionally, the State through various forms, could also fund transmission upgrades. This could be done through a variety of methods; however, there is risk that comes with any investment of this kind that would need to be addressed and studied prior to moving forward.

OPPORTUNITIES FOR FUTURE STUDY

This stakeholder process clearly brought to light the complexities of the transmission system and potential challenges for renewable energy development presented by the constraints on the system. In order to fully understand the impact of these constraints, the cost of potential solutions, and the economic impact of pursuing those potential solutions, additional funding would be required for a more in-depth future study.

In particular, the second requirement of this study to "examine a minimum of 4 different renewable energy development scenarios that vary by total generation capacity, resource type and site location, taking into consideration the impact on siting and ratepayers and the relative benefits of different scenarios for energy consumers, transmission costs, existing generators, developers of new renewable energy resources and the environment" would require in-depth analysis requiring additional funding. The exact cost of that analysis would depend on the specifics of the request and likely the cost of an outside consultant.

ISO-NE does provide the opportunity for stakeholders to submit economic study requests, which they perform with no direct cost to the requesting entity. This study opportunity provides a forum for stakeholder review of the impact of alternative future New England system scenarios, including: economic evaluations, environmental emissions analysis, and potential economic benefits of relieving transmission constraints. More information can be found on the ISO-NE website, along with past and current study projects, including the NESCOE and RENEW requested studies mentioned in this report.

Additionally, in the Stipulation for Central Maine Power's (CMP) Petition for Certificate of Public Convenience and Necessity (CPCN) for the New England Clean Energy Connect transmission project, CMP and NECEC LLC agreed to study the impact of the proposed transmission line on the transmission system. This includes participation in an ISO-NE study to determine the thermal, voltage and stability

[34] PretiFlaherty. (June 1, 2017). *PretiFlaherty Energy Policy Update: New England Regional Renewables Procurement.* Retrieved from http://energypolicyupdate.blogspot.com/2017/06/new-england-regional-renewables.html

ratings for the Surowiec-South interface with the goal to maximize the stability rating and transfer capacity at that interface. In addition, a set of stakeholders would also engage a transmission consultant to evaluate potential transmission and non-wires alternatives, and their costs, to help reduce existing and projected congestion at the Maine/New Hampshire interface and the Surowiec-South interface. This study would be paid for by CMP, with the expense not to be recovered by ratepayers. If a cost effective and commercially viable transmission and non-wires alternative solution(s) are identified for the Maine/New Hampshire and/or Surowiec-South interface, CMP agreed to assess and pursue potential means and cost-allocations for those upgrades, such as a Reliability Transmission Upgrade, Market Efficiency Transmission Upgrade or a Public Policy Transmission Upgrade (all described in the *Funding Mechanisms* section of this report). This study would commence as soon as all necessary permits and approvals are received by CMP and Hydro-Quebec. Finally, within one year after completion of the development of the transmission line, CMP agrees to produce an annual electric transmission and distribution system report analyzing the potential needs of the system that can be met through non-wires alternatives.[35] These studies would provide additional data and information regarding some of the constraints, and potential future constraints, described throughout this report.

CONCLUSION

Transmission and distribution systems are vital components of renewable energy development. Without access to the grid, there are limited options for using or selling electricity generation. Most generation requires access to the grid for participation in the electricity markets provided by ISO-NE, whether energy, capacity and/or ancillary markets. Current constraints on Maine's transmission - and potentially distribution - systems may be restricting renewable energy development, and in some instances, preventing generators from participating in certain markets, thus restricting them from obtaining additional funding mechanisms. This report explains the current system, constraints on that system, options for funding upgrades to the system to relieve constraints, and where more in-depth studies may be useful. The energy sector is in the middle of a rapid transformation and Maine has set ambitious renewable energy goals. Maine will continue to work with ISO-NE, as well as the other New England states when appropriate, to understand the impact of these goals on the electric grid and to identify opportunities to address challenges that arise.

[35] State of Maine Public Utilities Commission. (February 2019). *Central Maine Power Company, Request for Approval of CPCN for the New England Clean Energy Connect Consisting of the Construction of a 1,200 MW HVDC Transmission Line from the Quebec-Maine Border to Lewiston (NECEC) and Related Network Upgrades: Stipulation.*