MARKET AND ENVIRONMENTAL BENEFITS OF NEW ENGLAND RENEWABLE GENERATION

DECEMBER 20, 2022

PREPARED FOR
American Clean Power Association

PREPARED BY
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ABOUT THIS REPORT

This report was funded by the American Clean Power Association and reflects Daymark's independent assessment of the benefits of the development of incremental renewable generation in New England. In conducting this assessment, Daymark relied on publicly available data and our considerable experience evaluating the economics of generation and transmission infrastructure under current and future market and policy conditions.

The analyses supporting the results presented here involve the use of assumptions and projections with respect to conditions that may exist or events that may occur in the future. Although Daymark Energy Advisors has applied assumptions and projections that are believed to be reasonable, they are subjective and may differ from those that might be used by other economic or industry experts to perform similar analysis. In addition, actual future outcomes are dependent upon future events that are outside Daymark Energy Advisors' control. Daymark Energy Advisors cannot, and does not, accept liability under any theory for losses suffered, whether direct or consequential, arising from any reliance on this presentation, and cannot be held responsible if any conclusions drawn from this presentation should prove to be inaccurate.

I. EXECUTIVE SUMMARY

Incremental renewable capacity continues to provide significant and quantifiable benefits to the New England grid and its customers. In this report, Daymark Energy Advisors (Daymark) analyzed the market and environmental benefits of 1,200 megawatts (MW) of incremental land-based renewable capacity for the New England region. The results demonstrate that the benefits of renewables accrue broadly throughout the region through the reduction in energy prices and reduced greenhouse gas emissions, and that all states yield benefits regardless of the specific contracting circumstances for the output of the resources.

In this report, Daymark evaluated two portfolios of incremental renewable resources: 1,200 MW of land-based wind (the “Wind Only” case), and a portfolio of 900 MW of land-based wind and 300 MW of solar (the “Wind+Solar” case). Daymark modeled these resources using our New England production cost model built on the PLEXOS modeling platform over a 20-year study period. For modeling purposes, the resources were sited in Maine, where most planned large-scale renewable projects are located.

Market benefits

The addition of renewable resources on the grid can reduce the need for ISO New England (ISO-NE) to dispatch more expensive generation, lowering market prices and providing significant energy cost savings. In this report, these savings are referred to as the Market Benefits.

The results show that the addition of the renewable portfolios provides significant long-term Market Benefits for customers, lowering the wholesale cost of energy in all New England states.

Figure 1 summarizes the levelized annual wholesale energy cost savings (in millions), by state, for each of the modeling cases over the 20-year study period.[1]

[1] Benefit values in this report are discounted back from the study period (2029-2048) to 2022 using a discount rate of 7%. All dollar values are reported as 2022$.

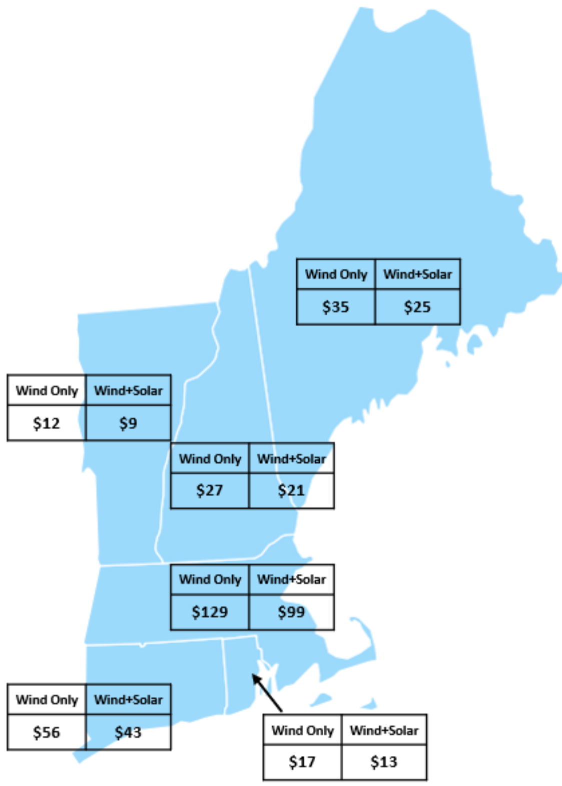

Figure 1. Levelized annual wholesale market savings by state, 2029-2048 ($ millions)

Environmental benefits

In addition to lowering costs of energy supply, the addition of the renewable resources reduces the total regional emissions from the power supply sector. The renewable energy displaces energy from oil- or natural gas-fired resources, avoiding emissions from the least efficient resources.

Figure 2 summarizes the average annual CO_2 emissions savings by state for each modeling case over the 20-year study period, in thousands of tons. As discussed in more detail in Section IV of this report, these values are calculated as each state's load-ratio share of total ISO-NE system emissions.

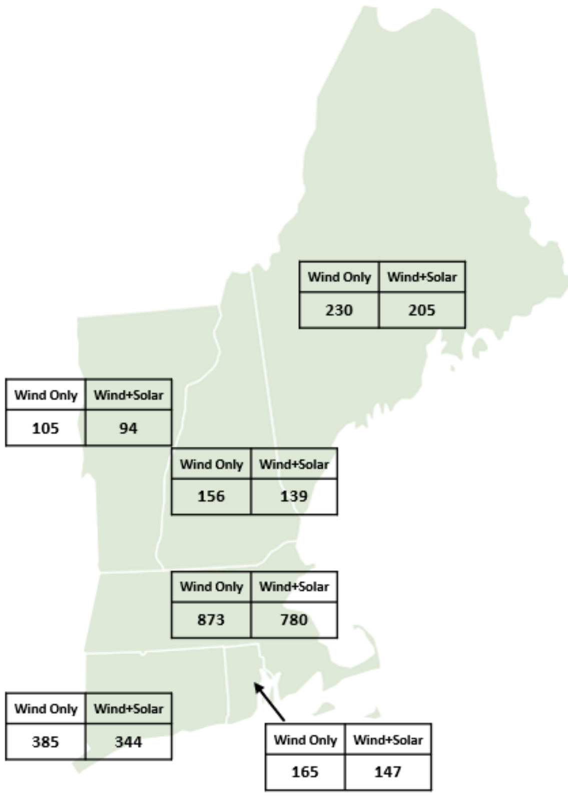

Figure 2. Average annual emissions savings, load-ratio share (thousand tons)

These results demonstrate the significant environmental benefits delivered by the incremental renewable resources, helping states achieve their state policy goals.

II. STUDY OVERVIEW AND CONTEXT

As New England states pursue economy-wide electrification and decarbonization, the power supply sector will be the foundation of a cleaner future. The continued addition of new renewable resources is a key component of achieving state policy goals, but also provides meaningful and quantifiable economic and environmental benefits.

American Clean Power contracted Daymark to conduct an analysis of the market and environmental benefits of new large-scale renewable development in New England. This study is intended to quantify the wholesale energy market benefits and emissions-related benefits of 1,200 MW of new land-based renewable resources.

Daymark's analysis utilized our New England system model based on the PLEXOS production cost modeling database. PLEXOS is an industry-standard simulation model used by utilities, ISOs and RTOs, consultants, and researchers throughout the energy industry. For this study, Daymark used the zonal modeling configuration.[2] The model includes up-to-date assumptions of new resource additions and uses the most recent ISO-NE forecast of load growth in the region considering electrification projections.

With this New England model, Daymark studied two cases: a "Wind Only" case with 1,200 MW of land-based wind, and a "Wind+Solar" case with 900 MW of land-based wind and 300 MW of new solar. The incremental resources were sited in Maine, which is the location of most proposed large-scale, land-based renewable project in New England (particularly wind). Daymark also modeled sufficient upgrades to the transmission system to deliver the energy to load centers in southern New England. The portfolios were modeled for a 20-year study period with an in-service year of 2029.

III. MARKET BENEFITS

The addition of incremental renewable capacity delivers energy price benefits to all New England states. As a large source of low-cost, non-emitting energy, the addition of the renewable projects will reduce the region's demand for the most inefficient and expensive grid resources, thereby reducing wholesale market prices. As described below, avoiding the dispatch of these most expensive "marginal" resources generally reduces prices region wide. This report refers to those price reductions as the Market Benefits.

2 The Technical Appendix attached to this report provides more information about PLEXOS and the modeling assumptions used in this analysis.

Although the modeled projects are located in Maine, the ISO-NE market is operated and dispatched as an integrated system, and thus the wholesale price reduction benefits will accrue across the region. This will provide benefits to all purchasers of market energy (including residential and commercial/industrial customers), not just the counterparties of the renewable PPAs.

Background

In the ISO-NE system, generating resources are centrally dispatched by ISO-NE and hourly prices are generally set by the highest-cost resource at any given moment. Prices are set at the substation level for each of the hundreds of pricing nodes on the system (currently over 1,100 individual nodes). These locational marginal prices (LMPs) are differentiated due to congestion and losses on the system, but they are all set through the same process of quantifying the cost of the most expensive generator online at a given time and the cost of delivering that power to each pricing node location. By market settlement rules, the LMPs are the prices for both load purchases and generator compensation, so these clearing prices have broad effects to all participants in the market.

Renewable resources generally bid into energy markets as price-takers, or even with negative pricing, to ensure that their output is not curtailed. The addition of these resources has the effect of displacing the most expensive units that would otherwise be dispatched and setting the LMPs throughout the region. Since all load is priced by the LMPs, by displacing these highest-priced resources, the addition of renewables can lower the LMPs throughout the region and provide savings for every MWh of energy purchased on the market. In addition, unlike oil-and natural gas-fired resources, renewable resources are not susceptible to volatile fuel prices, and contribute to more pricing stability in the energy market.

It is important to note that this LMP benefit is distinct and separate from the potential contractual benefits of renewables that accrue to the purchaser of the project output. If the project output is contracted through a power purchase agreement (PPA), the buyer receives energy at a fixed price. To the extent this fixed price is below market prices, the buyer will receive contractual benefits. This benefit is specific to the cost of the generation project and the contract terms, which were not assumed for this study. Therefore, direct contract benefits are not quantified in this Market Benefits analysis.

Benefit methodology

To calculate the benefit of incremental renewable resources, Daymark conducted production cost modeling to produce LMP forecasts with and without the new renewable resources. This industry standard methodology looks at a future without the new resources as a "base case" and then compares that base to a "change case" with the resources to calculate incremental market benefits of the new resources.

Daymark's modeling analysis produced hourly zonal energy prices for both the Base Case and two Change Cases (one for each of the portfolios: Wind Only and Wind+Solar). By comparing the results of the Change Cases to the Base Case, we quantified the benefits to ratepayers over the twenty-year study period. Multiplying the forecasted change in load-weighted LMPs by the market purchases for each state returns the total wholesale load cost benefit resulting from the addition of the renewable resources.

This calculation provides a high-level estimate for the change in cost of wholesale energy to load. While not a perfect reflection of the impact to ratepayers, change in wholesale energy costs to load is an important driver of customer costs.

The first reason that change in wholesale costs are not the same as change in customer costs is that most customers do not pay for energy based on the day-ahead or real-time wholesale rate. Rather, they pay supply prices that are pre-determined through their supplier. This may be a competitive supplier, or a default service provider.[3]

The second reason is that the calculation of wholesale cost to load impact ignores the fact that there are energy purchases under long-term contract in each state. Several New England states have conducted competitive procurements for renewable resources, or have otherwise entered into long-term purchase agreements for energy. This includes the long-term contracts for offshore wind recently conducted, or the long-term contract with the Millstone nuclear plant in Connecticut. Those contracts effectively set fixed prices for a portion of energy supply in those states, which would not be directly impacted by a change in statewide LMPs.

Wholesale energy cost impacts remain a valuable metric despite these two factors because over time, changes in the wholesale energy market are reflected in both the default service rate of power and any future contracts for power that the states might

3 "Default service providers" are known by multiple names depending on the state, including "Standard Offer Providers," "Basic Service Providers," or "Providers of Last Resort."

choose to incur. This makes the change in wholesale energy costs a good indicator of the long-term impact of new energy resources on customer costs.

Results

The results of the analysis demonstrate that the additional renewable resources will deliver significant market benefits to each New England state through the reduction in LMPs. Using the PLEXOS pricing results and a forecast of market purchases, the analysis shows that the levelized total regional savings are $277 million per year for the Wind Only Case and $210 million per year for the Wind+Solar case. On an NPV basis over the 20-year study period, this totals $2.9 billion in the Wind Only case and $2.2 billion in the Wind+Solar case for the region. Figure 3 and Figure 4, below, summarize the state-by-state results.

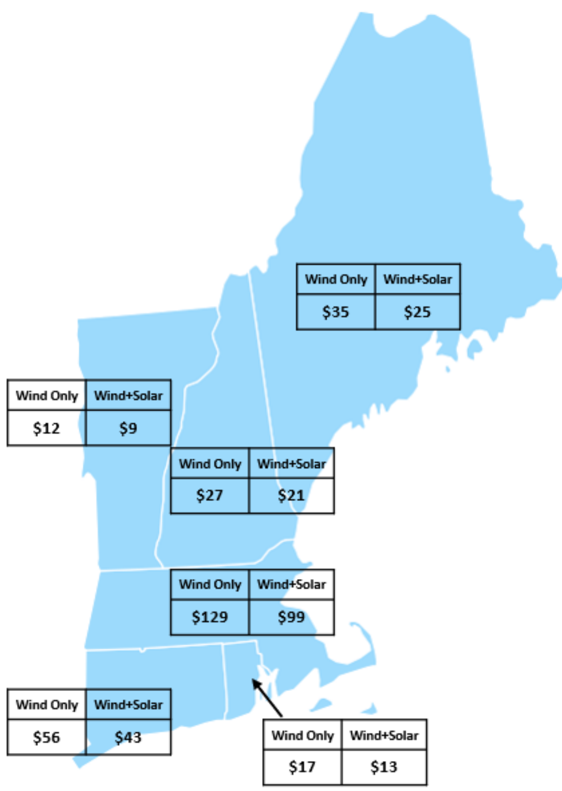

Figure 3. Levelized annual wholesale market savings by state, 2029-2048 ($ millions)

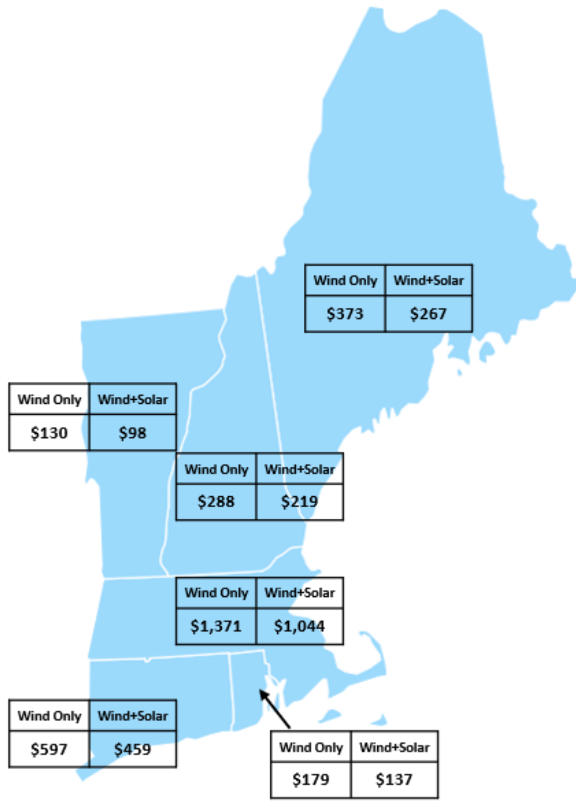

Figure 4. Total wholesale market savings by state, 2029-2048 (NPV, $ millions)

These market benefits are based on a change in the per-MWh price of energy multiplied by the amount of energy purchases impacted by the price change. States with higher loads, such as Massachusetts and Connecticut, receive the majority of these benefits because they use the majority of the energy. These results demonstrate that even though the specific resources studied in this analysis are located in Maine, the benefits accrue throughout the region. The specific benefit values would be different if the incremental generation was modeled in western Massachusetts (for example), but the same principle would apply; incremental infra-marginal resources will generally lower prices across the region and deliver benefits to customers in all states.

The differences in results for the Wind Only and Wind+Solar cases are driven by two factors. First, the Wind Only case has more incremental renewable energy because the capacity factor for wind resources is higher than for solar resources. In addition, the daily and seasonal profiles are resource-specific, so the impact on regional LMPs will be different for each resource type (i.e., wind typically generates more power in winter, solar in summer).

IV. ENVIRONMENTAL BENEFITS

In addition to providing significant economic benefits, the addition of renewable resources provides significant environmental benefits in the form of reduced emissions. The driver of these benefits is consistent with the driver of the economic benefits in that the addition of the renewable resources reduces the dispatch of other resources. In New England, as in most regions, the highest cost resources (and the first to be displaced when renewables are added) are typically inefficient fossil fuel-fired resources, including oil- and natural gas-fired plants.

In this analysis, Daymark quantified the reduction in CO_2 emissions due to the addition of the 1,200 MW of new renewable capacity. The reduction in emissions is calculated as an output of the same PLEXOS production cost modeling that produced the economic benefits calculations.

The figure below summarizes the average annual emissions savings in each state resulting from the addition of the incremental renewables over the 20-year study period.

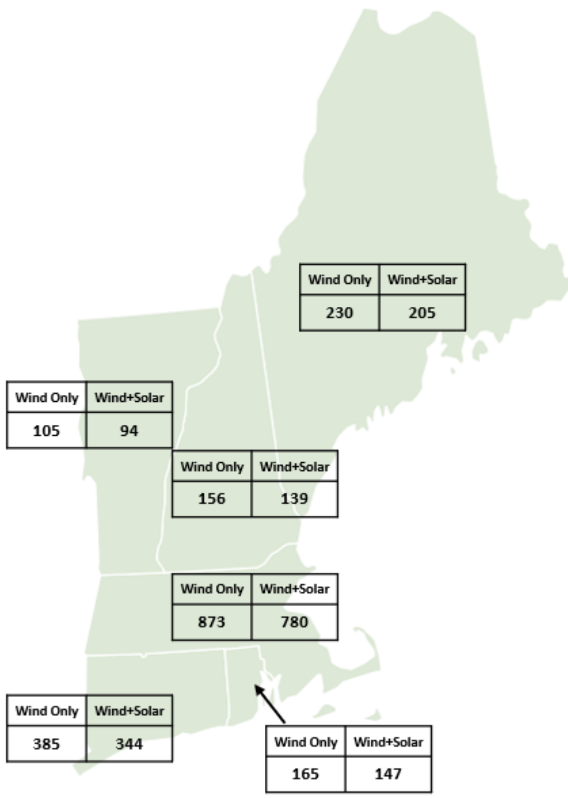

Figure 5. Average annual emissions savings, load-ratio share (thousand tons)

These results show the reduction in emissions based on each state's load-ratio share of total system emissions. This recognizes the fact that all generators in the region are centrally-dispatched by ISO-NE to minimize costs and maintain reliability across the region, and allocates emissions based on each state's proportional share of total energy consumption.

Another method of accounting for emissions is to quantify the reduction in emissions from power plants within the borders of each state. The table below compares the emissions reduction results under the two methods for each scenario.

Table 1. Summary of average annual emissions reduction (thousand tons)

	WIND ONLY CASE		WIND+SOLAR CASE	
	SHARE OF TOTAL ISO-NE EMISSIONS REDUCTION	EMISSIONS REDUCTION FROM IN-STATE GENERATORS	SHARE OF TOTAL ISO-NE EMISSIONS REDUCTION	EMISSIONS REDUCTION FROM IN-STATE GENERATORS
Connecticut	328	396	293	365
Maine	193	267	172	227
Massachusetts	739	376	661	339
New Hampshire	132	124	118	112
Rhode Island	139	449	125	398
Vermont	89	8	80	6

Some states show a significant difference in the results due to the composition of the in-state generating resource portfolio. In both cases, the addition of the incremental renewables produces significant emissions savings for each state.

V. CONCLUSION

Each New England state is pursuing a cleaner energy portfolio as the region continues to advance towards a lower-carbon economy, and the addition of substantial new renewable resources will become increasingly important as the heating and transportation sectors electrify. Given the integrated nature of the ISO-NE grid and the centralized dispatch of generation resources, these new renewables will provide significant economic and environmental benefits to the entire region.

As detailed in this study, new wind and solar resources will provide near-term and long-term energy cost savings and allow for the reduced dispatch of the most emitting regional resources, laying the groundwork for the carbon-free future grid.

TECHNICAL APPENDIX: MODELING METHODOLOGY

Daymark designed the evaluation methodology, including the selection of tools and the analytical approach, to quantify specific market and environmental benefits of New England renewable resources. In designing the methodology, we relied on our experience conducting similar analyses for prior procurements, as well as our experience in competitive resource procurements for renewable capacity and transmission in other states. This section provides a description of the methodology used to evaluate the benefits of the two portfolios, as well as a description of the tools and key assumptions used.

A. Daymark expertise and experience

Daymark is a leading provider of integrated policy, planning, and strategic decision support services to the North American electricity and natural gas industries. Our firm serves a mix of clients across North America, including utilities, infrastructure developers, energy suppliers, energy consumers, and regulators. We have provided our clients with the highest quality actionable analysis and advice to support efficient and sustainable decisions under uncertainty for over 40 years.

We offer specialized knowledge and understanding of the design, operation, and performance of organized wholesale electricity markets and power systems and expertise in the evaluation of the economics of generation and transmission infrastructure under current and future market and policy conditions. To provide analytical support of these services, we have a range of in-house market modeling capabilities, including both commercially licensed models (PLEXOS) and custom proprietary models that we use regularly to forecast market prices, generation production and emissions, generator entry and exit, and other market performance metrics. Our experts advise clients on matters including cost-benefit analysis, economic modeling and forecasting, resource planning, project due diligence, and energy procurement.

B. Analytical methodology overview

Daymark has evaluated the economic, market, and emissions benefits of multiple infrastructure projects, including both renewable capacity and transmission, in multiple states. Over the course of these evaluations, Daymark has developed a comprehensive methodology to isolate and quantify a range of unique project benefits. We have applied this methodology to assess the various benefits of Maine renewable energy and transmission development to Maine and Massachusetts ratepayers as well as the ISO-NE region.

We used a "with and without" approach, in which we analyze a future world without the infrastructure development (the Base Case) and future worlds with the infrastructure development in service (the Change Cases; Wind Only and Wind+Solar). The comparison of these cases allows us to quantify the impact of infrastructure development on a variety of metrics.

C. Models and tools

Daymark's methodology relies on a variety of analytical models and tools. The primary model is Daymark's Northeast Market Model (NMM), which is based on the commercially licensed PLEXOS production cost model, described below. In addition to this model, Daymark developed custom spreadsheet tools to quantify various benefits.

Northeast Market Model

Production cost modeling analysis was performed using the NMM. The Daymark NMM uses an hourly chronologic electric energy market simulation model based on the PLEXOS software platform licensed through Energy Exemplar. The model provides a zonal representation of the electrical system of New England, with market-based simulation of interchange opportunities with surrounding control areas.

The underlying technology, PLEXOS, is a well-established, industry-standard simulation model that uses and captures the effects of multi-area, transmission-constrained dispatch logic to simulate real market conditions. The PLEXOS model captures the dynamics and economics of electricity markets. PLEXOS realistically approximates the formation of hourly energy market clearing prices on a zonal basis using all key market drivers, including fuel and emissions prices, loads, demand-side management (DSM) impacts, generation unit operating characteristics, unit additions and retirements, and transmission congestion and losses.

The NMM uses a New England carve-out from a comprehensive database representing the entire Eastern Interconnect (the North American interconnected power system east of the Rocky Mountains), including representations of power generation units, zonal electrical demand, and transmission configurations. Several key assumptions that are most pertinent to this analysis are described in the next section.

D. Key assumptions

The NMM relies on a multitude of input assumptions to provide realistic market simulations. This section highlights specific notes on key assumptions used in the analysis including transmission topology, load, generation, fuel prices, and greenhouse gas emissions.

Topology

The NMM is a zonal model where each defined zone represents a "bubble" of load and generation. Transmission is represented as single composite links between zones with constraints on certain combinations of links to realistically represent the interfaces. Key attributes that can be defined for each individual link are wheeling costs, transfer losses, and transfer capability (in MW). The topology of ISO New England and contiguous areas within the NMM are shown in Figure 6, below.

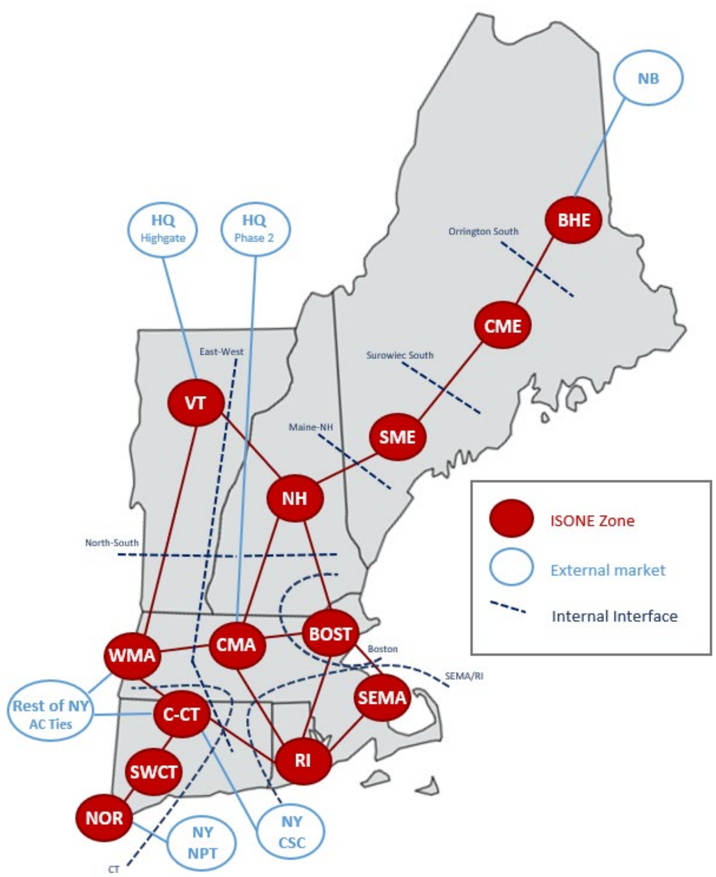

Figure 6. NMM Topology: ISO New England and regional interconnections

Due to uncertainty regarding regulatory conditions, the study did not include the New England Clean Energy Connect HVDC transmission project or associated incremental hydroelectric energy from Québec.

Load

The New England load forecast used in the NMM is based on the ISO New England load forecast for the CELT report.[4] Since the zones modeled in the NMM align with the Regional System Plan (RSP) zones, we used the forecast values by RSP zone directly from the CELT report.

For the forecast years through 2030, the CELT report forecasts gross peak and energy load, as well as peak and energy load net of energy efficiency (EE) and behind-the-meter solar photovoltaic (BTM PV) generation. For years after 2030, Daymark escalated net load using the compound annual growth rate.

Generation

Changes to the regional generation portfolio are critical inputs that impact the model simulations for long-term studies such as this. Daymark develops its generation assumptions considering known near-term resource changes (retirements and new resource additions), and develops long-term assumptions based on announced state policies and independent economic modeling impacting resource economics.

The most relevant state policies include renewable portfolio standards and resource-specific statutory procurement targets. For example, we build out sufficient renewable resources to ensure that each state's RPS is met, including the addition of specific resource types (such as offshore wind) that are the subject of specific state legislation.

For conventional capacity resource additions and retirements, Daymark assumes that resources that have cleared the capacity market will be brought online, and conducts capacity market modeling to estimate the timing of addition economic resource additions and retirements, subject to regional resource adequacy constraints.

As noted above, the study did not include the New England Clean Energy Connect HVDC transmission project or associated incremental hydroelectric energy from Québec.

[4] ISO-NE, "*Forecast Report of Capacity, Energy, Loads, and Transmission*," available at: https://www.iso-ne.com/system-planning/system-plans-studies/celt.

Fuel prices

Fuel price projections are key assumptions for the NMM and are subject to a large amount of uncertainty. As a key component of dispatch cost, fuel prices drive price formation and regional market dynamics. In the NMM production cost model, each generator is assigned a fuel price based on the type of fuel, unit type, and plant location.

The New England market is currently dominated by natural gas generation and that will likely remain the case for many years, particularly for the purposes of setting marginal energy prices. Therefore, the natural gas price assumptions are a critical driver to our modeling and results.

Daymark uses a combination of short- and long-term forecasts developed by the U.S. Energy Information Administration, as well as market-based forward prices from NYMEX. The Henry Hub and Algonquin City Gate price forecasts used in this analysis are depicted in Figure 7 below.

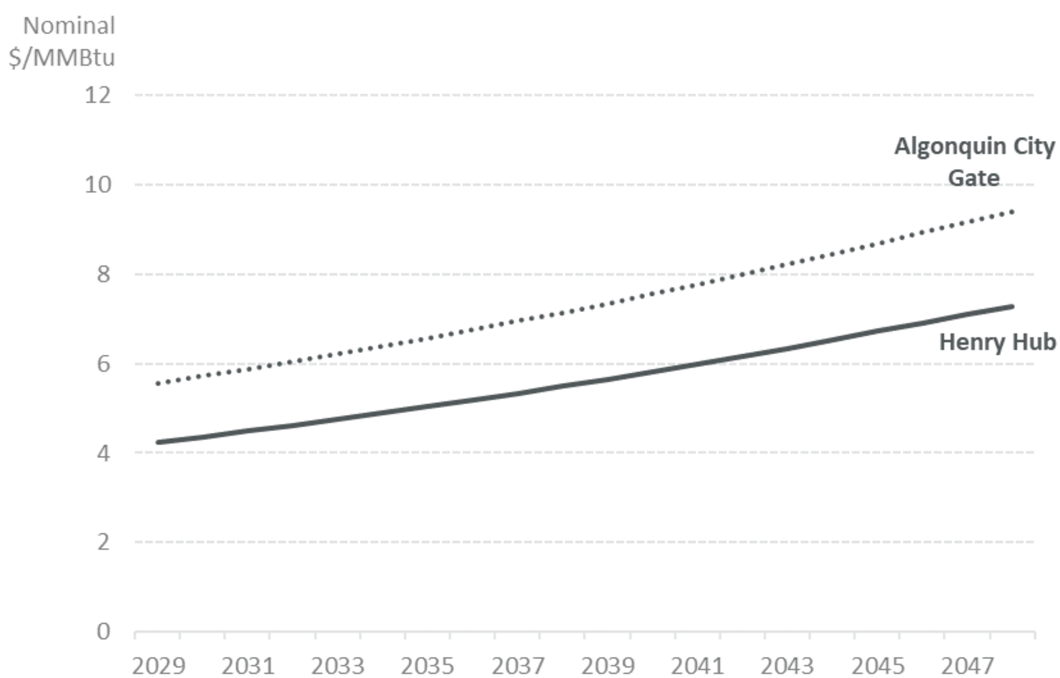

Figure 7. Henry Hub and Algonquin City Gate natural gas price assumptions

It is important to note that the natural gas price markets have been subject to significant and rapid change over the past year, and in particular since the beginning of the war in Ukraine. The volatility has resulted in quickly evolving long-term market expectations for natural gas pricing. Alternative long-term pricing scenarios were not evaluated in this study, but in general higher natural gas prices tend to increase the net benefits of renewable inframarginal resources.

Greenhouse gas emissions

The NMM incorporates emission prices into the production cost, commitment, and dispatch of units.

Our New England Base Case incorporates a forecast based on near-term forecast RGGI allowance prices, transitioning to a moderate federal carbon dioxide (CO_2) price policy beginning in 2027.

The CO_2 price assumptions are summarized in Figure 8.

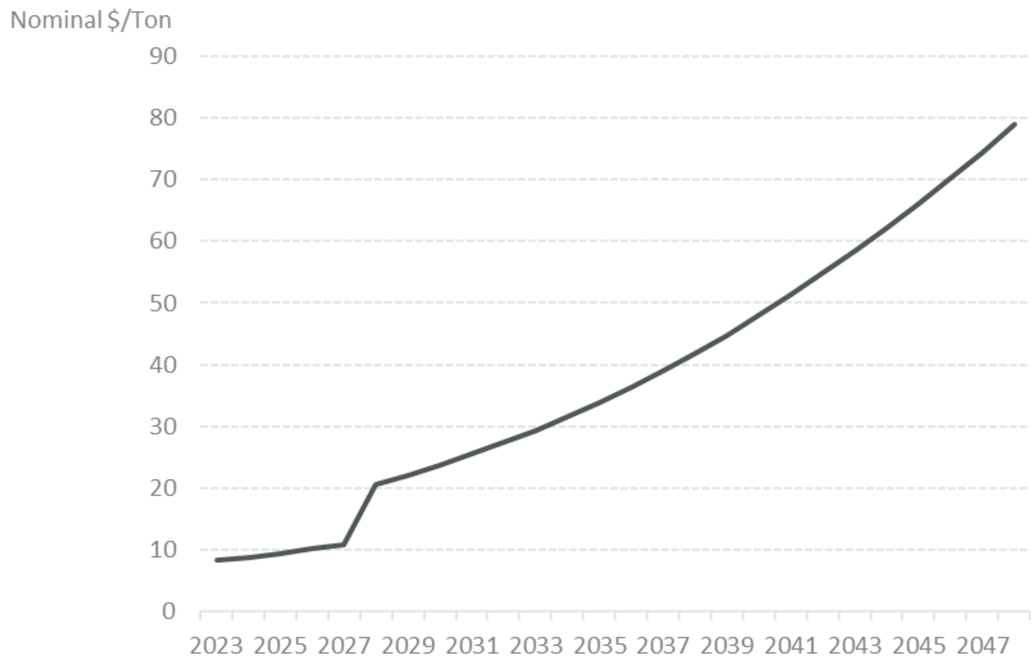

Figure 8. CO_2 price outlook