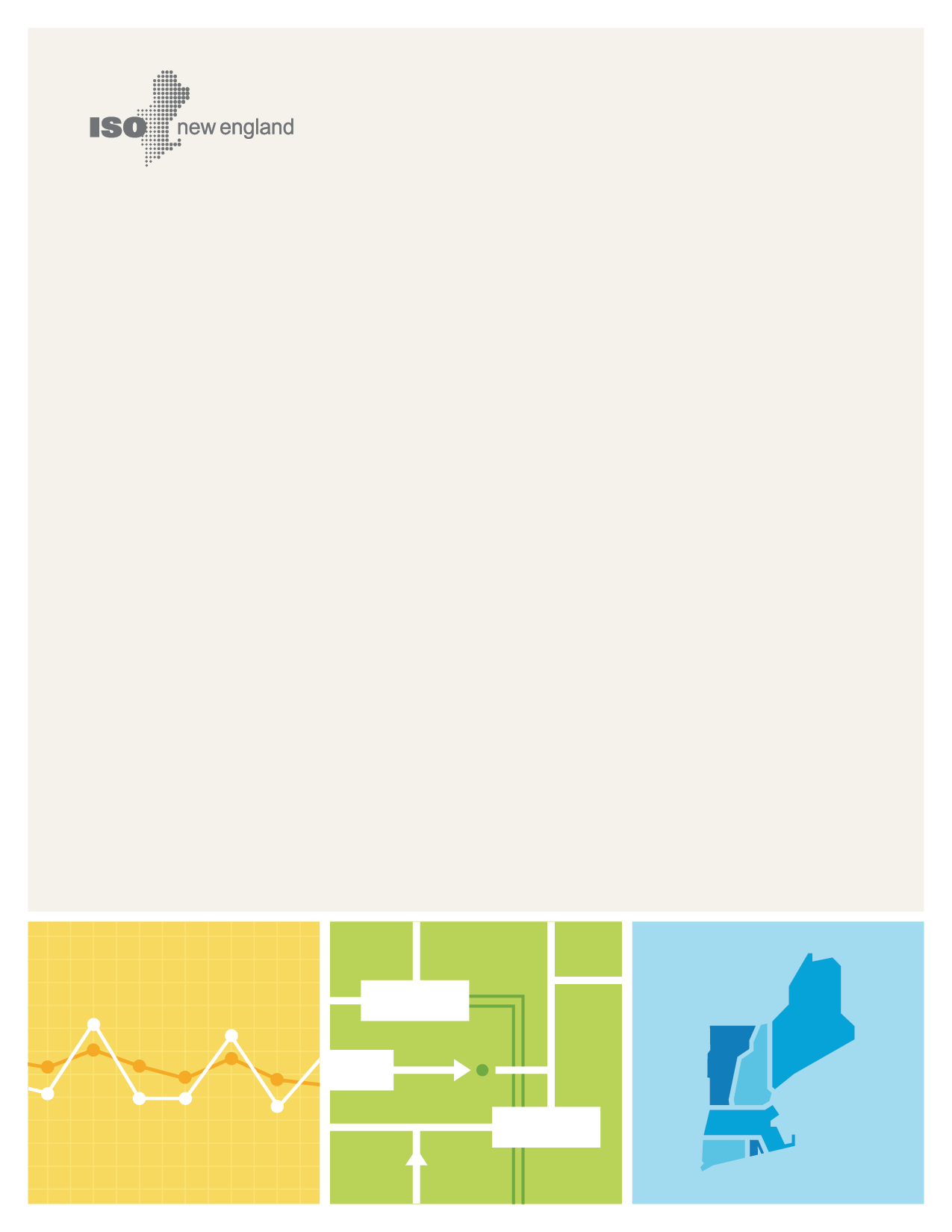
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**2019 Economic Study:**

**Significant Offshore Wind Integration**

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# Executive Summary

This report documents the *Significant Offshore Wind Integration* scenarios of the 2019 ISO New England (the ISO or ISO-NE) Economic Study conducted for the ISO’s stakeholders following a request by Anbaric Development Partners, LLC (Anbaric). The 2019 Anbaric Economic Study request was for the ISO to study the impacts on energy market prices (i.e., production cost analysis), air emissions, and regional fuel security when the system experiences large penetrations of offshore wind resources. The study included offshore wind projects under development and under contract at the time of the Anbaric request, considering cases with 8,000 megawatts (MW), 10,000 MW, and 12,000 MW of offshore wind strategically placed in southern New England as well as interconnected from an offshore collection substation directly to the Mystic substation in Boston, Massachusetts. Anbaric requested additional interconnection cases that spread offshore wind injections along the Connecticut shore into southwestern Connecticut, but these cases were not studied to increase study efficiencies and focus on optimal injection locations.

The 2019 Anbaric Economic Study used results from an analysis performed for the NESCOE 2019 Economic Study and base case assumptions but additionally included parameters such as nearly 4,500 MW of generator retirements and the addition of 2,000 MW of 4-hour battery storage (8,000 megawatt-hours; MWh).[[1]](#footnote-2) A sensitivity was performed on the 10,000 MW of offshore wind scenario (10000\_Sen), with increased demand due to electrification (i.e., the addition of electric vehicles and heat pumps) and additional supply in the form of battery storage. While the request sought to reduce nuclear output by taking the Millstone station in southeast Connecticut off line, this study instead reduced Millstone’s output by 1,000 MW and Seabrook’s output by 1,000 MW to align the assumptions with the NESCOE study and improve study efficiencies.

The results for the production cost analyses indicate that energy-production costs are reduced by approximately one-half with the interconnection of 8,000 MW of offshore wind. Similarly, system carbon dioxide emissions are reduced by approximately one-third with 8,000 MW of offshore wind. The study used the results from the 2019 NESCOE Economic Study, which showed the following for the 2030 study-year topology:

* Approximately 7,000 MW of new offshore wind has the potential to be interconnected without major additional 345 kV reinforcements, 5,800 MW to the southern shore substations and 1,200 MW to the Mystic station in Boston.[[2]](#footnote-3)
* Interconnecting more than 5,800 MW of offshore wind inside the Southeast Massachusetts (SEMA) and Rhode Island (RI) subareas increases congestion of the SEMA/RI export interface

As more offshore wind is interconnected into southeastern Massachusetts, the amount of spillage increases due to oversupply (i.e., supply exceeding demand), given the transmission system’s current ability to move power out of the area. The retirement of large baseload must-run (e.g., nuclear) generation would lower spillage associated with oversupply as well as with transmission congestion. As observed in the, 10000\_Sen scenario, the increased electrification and installation of more storage in areas with a large amount of offshore wind development (e.g. SEMA, RI, and Boston) would reduce congestion of the SEMA/RI export interface compared with installing storage resources elsewhere.

# Background and Purpose of the 2019 Anbaric Economic Study

The 2019 Anbaric Economic Study was one of three economic studies submitted to the ISO in 2019.[[3]](#footnote-4) The other two economic study requests were from RENEW and NESCOE discussed in separate reports and presentations accordingly.[[4]](#footnote-5)

As a part of the regional system planning effort and as specified in Attachment K of its *Open-Access Transmission Tariff* (OATT), the ISO may conduct economic planning studies each year.[[5]](#footnote-6) Using scenario analysis, the economic studies provide information on system performance, such as estimated production costs, load-serving entity (LSE) energy expenses, transmission congestion, and environmental emission levels.[[6]](#footnote-7) Scenario analyses also inform stakeholders about different future systems. These hypothetical systems should not be regarded as physically realizable interconnection plans or the ISO’s vision of future development, projections, and preferences. Study scenarios include assumptions that may not reflect laws or policies that will be in effect for the study year, but they can assist readers by identifying key regional issues.

The ISO conducts economic studies under the auspices of the Planning Advisory Committee (PAC). The role of the PAC in the economic study process is to discuss, identify, and otherwise assist the ISO by advising on the proposed studies.[[7]](#footnote-8) For this study, stakeholders and the study proponent, Anbaric, shaped the scope of work, although the ISO did not study all of Anbaric’s requests and modified some assumptions (e.g., nuclear retirements and the rejection of broader interconnection points) to align the NESCOE and Anbaric studies and improve study efficiencies; see Section 4.

The Anbaric request was for the ISO to analyze scenarios of high penetrations of offshore wind to determine the impacts on energy market prices, air emissions, and regional fuel security for 2030. This study examined three scenarios of varying amounts of offshore wind interconnections—one with additional wind, electric vehicles, and heat pumps—and four sensitivities to the four scenarios. Anbaric requested additional interconnection cases that spread offshore wind injections along the Connecticut shore into southwestern Connecticut, but these cases were not studied to increase study efficiencies and to focus on optimal injection locations. The ISO also did not perform the portion of Anbaric’s request to study the impact of high penetrations of offshore wind resources on fuel security using the ISO’s fuel-security reliability tool because the Anbaric study is for the 2030 timeframe and well outside the period in which the tool was designed to be used.[[8]](#footnote-9)

Study results were presented to the PAC on March 18, 2020, and May 20, 2020.[[9]](#footnote-10) A follow-up presentation regarding energy-storage modeling (batteries and pumped-storage hydro resources) was posted with the June 17, 2020, PAC materials.[[10]](#footnote-11) The aim is for the results to inform developers, consumer interest groups and advocates, policymakers, and regulators and be useful as they develop strategies to meet the region’s renewable energy goals. The ISO encourages interested parties to compare the results for the different scenarios and to reach their own conclusions about the possible implications.

The report includes hyperlinks throughout to PAC presentations and other materials that contain more detailed information. Some of these links are for materials containing Critical Energy Infrastructure Information (CEII).[[11]](#footnote-12) These links are up to date as of the publication of the report.

# Scenarios

For this study, the ISO considered three offshore wind penetration scenarios: 8,000 MW, 10,000 MW, and 12,000 MW (nameplate), including offshore wind strategically placed in southern New England and interconnecting in the Boston, Massachusetts, area.[[12]](#footnote-13) A fourth scenario was studied that included 10,000 MW of offshore wind as well as increasing demand due to electrification (i.e., the addition of electric vehicles and heat pumps), and adding supply and demand in the form of battery storage., In addition, a reference case was developed where no new offshore wind resources were considered. The scenarios evaluated the 2030 study year.

Sensitivities were performed to the four requested scenarios to identify the impact of differing curtailment orders of the New England Clean Energy Connect (NECEC) (i.e., an assumed new tie from Québec). For the sensitivities, the NECEC threshold price was increased from $2/megawatt-hour (MWh) to $11/MWh, meaning that NECEC would be curtailed before assumed native New England wind and imports.[[13]](#footnote-14)

The study accounted for offshore wind projects under development and under state contract at the time of the Anbaric request. This study included the retirement of nearly 4,500 MW of fossil and nuclear generation and the addition of 2,000 MW of 4-hour battery storage (8,000 MWh). The study used the results from an analysis performed for the NESCOE 2019 Economic Study, which showed that with the expected transmission topology for the 2030 study year, approximately 7,000 MW of new offshore wind (5,800 MW connected to the southern shore substations and 1,200 MW connected to the Mystic station in Boston) has the potential to be interconnected without major additional 345 kV reinforcements.[[14]](#footnote-15)

Table 3‑1 summarizes the simulated scenarios for the 2019 Anbaric Economic Study.

Table 3‑1  
Offshore Wind Integration Scenarios for the 2019 Anbaric Economic Study

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Scenario** | **Gross Demand, EE, Behind-the-Meter PV (Nameplate), Utility Scale PV (Nameplate)** | **Supply  (incl. Demand Resources)** | **Retirements** | **RFP-Committed Generation** | **Offshore Wind Additions Above RFP-Committed (Nameplate MW)** | **Demand from Heat Pumps (MW)** | **Demand from Electric Vehicles** | **Battery Storage Additions (MW)** |
| **Anbaric\_0**  **(Reference)** | Based on 2019 CELT Forecast(a) | 2019 CELT generators and FCA 13 cleared resources | FCA 13,  Mystic 8 and 9, 2,000 MW of nuclear  generation,(b) 2,494 MW of  oil units in CT and ME(c) | NECEC (1,090 MW of firm import; 0 MW of offshore wind(d) | 0 MW | None | None | 2,000 MW |
| **Anbaric\_8000** | NECEC (1,090 MW of firm import), 2,300 MW of offshore wind (nameplate)(e) | 5,700 MW |
| **Anbaric\_10000** | 7,700 MW |
| **Anbaric\_12000** | 9,700 MW |
| **Anbaric\_10000\_Sen**  **(Electrification)** | 7,700 MW | 2,050 MW | 550,000 vehicles(f) | 4,000 MW |

(a) For all scenarios, the ISO’s *2019 Forecast Report of Capacity, Energy, Loads, and Transmission* (CELT Report) (<https://www.iso-ne.com/static-assets/documents/2019/04/2019_celt_report.xls>) was the source for data on gross demand, energy efficiency (EE), and behind-the-meter photovoltaics (BTM PV) (April 30, 2019), [https://www.iso-ne.com/static-assets/documents/2019/04/2019\_celt\_report.xls](%20https:/www.iso-ne.com/static-assets/documents/2019/04/2019_celt_report.xls). Supply-side resource capacity (for new and existing generation and demand) was based on the results of the thirteenth Forward Capacity Auction (FCA 13) for the 2022-23 capacity commitment period; see *ISO New England Inc., Docket No. ER19-\_\_\_-000*, FERC filing (February 28, 2019), <https://www.iso-ne.com/static-assets/documents/2019/02/fca_13_results_filing.pdf>.

(b) Generation at Seabrook and Millstone reduced by a total of 2,000 MW, proportionally to their seasonal claimed capability.

(c) No more oil units assumed to be in Connecticut and Maine. All remaining oil units are located in New Hampshire.

(d) The transfer limit of the Surowiec South interface is kept at 1,500 MW in the Anbaric study.

(e) The total includes Massachusetts’ request for proposals (RFPs) from Vineyard Wind I (800 MW by 2023) and Mayflower Wind (800 MW by 2025), Connecticut RFPs from Revolution Wind (300 MW by 2023), and Rhode Island RFPs from Revolution Wind (400 MW by 2023). Park City Wind (804 MW by 2025) from Connecticut was not included because it was procured in December 2019 after the study assumptions were finalized.

(f) See Section 5.2.4, for the load assumptions for electric vehicles.

The primary locations of new offshore wind resources were in US Bureau of Ocean Energy Management (BOEM) lease areas, off the shores of Massachusetts and Rhode Island, and in Wind Energy Areas (WEAs) on the Outer Continental Shelf (see Figure 4‑1).[[15]](#footnote-16)



Figure 4‑1: US Bureau of Ocean Energy Management lease areas showing the location of offshore wind sites and interconnection points used for the preliminary results.

The ISO contemplated onshore interconnection points for offshore wind based on the results of several interconnection studies conducted for projects in the ISO Interconnection Request Queue.[[16]](#footnote-17) Proposed locations are anticipated to use either AC cable connections or HVDC submarine transmission from the wind farm lease areas to coastal 345 kV substations. A detailed discussion regarding offshore wind interconnection points are available as part of the 2019 NESCOE Economic Study. For the production cost scenarios, varying amounts of offshore wind additions were studied. Table 4‑2 shows the interconnection points for the offshore wind scenarios.

Table 4‑2  
Interconnection Points for Offshore Wind Scenarios (MW)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Anbaric**  **Scenario** | **Interconnection Points (MW)(a)** | | | | | | |
| **Montville**  **(CT)** | **Millstone**  **(CT)** | **Kent County**  **(RI)** | **Brayton Point (SEMA)** | **Barnstable (SEMA)** | **Mystic**  **(Boston)** | **Total** |
| **Anbaric\_8000** | 800 | \_ | 1,000 | 1,600 | 3,400 | 1,200 | 8,000 |
| **Anbaric\_10000** | 1,300 | \_ | 1,500 | 2,600 | 3,400 | 1,200 | 10,000 |
| **Anbaric\_12000** | 1,300 | 1,000 | 1,500 | 2,600 | 3,400 | 2,200 | 12,000 |
| **Anbaric\_10000\_Sen**  **(Electrification)** | 1,300 | \_ | 1,500 | 2,600 | 3,400 | 1,200 | 10,000 |

1. CT refers to the Connecticut subarea; RI, the Rhode Island subarea; SEMA, the Southeast Massachusetts subarea; and Boston, the Boston subarea.

# Methodology and Assumptions

Assumptions drive the study results, and some assumptions have a greater impact on the results than others (i.e., threshold prices for various resource types). To gain efficiencies, the assumptions for all three economic studies submitted in 2019 were determined in concert. At the May 21, 2019, and August 8, 2019, PAC meetings, the ISO reviewed in detail the assumptions associated with the 2019 Anbaric Economic Study.[[17]](#footnote-18) A status update was given on November 20, 2019.[[18]](#footnote-19) This section highlights the importance of certain assumptions and how modeling was performed for the 2019 Anbaric Economic Study.

## Modeling Tools and Methodology

The analyses were conducted using ABB’s GridView economic-dispatch program. The program is a complex simulation tool that calculates least-cost, transmission-security-constrained unit commitment and economic dispatch under differing sets of assumptions and minimizes production costs for a given set of unit characteristics. The program explicitly models a full network, and New England was modeled as a constrained single area for unit commitment.[[19]](#footnote-20)

However, GridView is not a nodal load-flow program, and it does not show more detailed system issues that may arise within areas. Rather, it is a “pipe-and-bubble” tool (see Section 4.2.1) that primarily identifies system-transfer issues between RSP subareas. Therefore, it does not identify transmission system upgrades needed in the SEMA/RI area to move the amounts of wind studied into and within the area. These costs may be significant and influence where the optimal points of offshore wind interconnection should be.

The as-planned transmission system was used for estimating the system’s transfer limits for internal and external interfaces. The 2030 transfer capabilities for internal and external transmission interfaces were based on the values established for 2025 for FCM and regional planning studies.[[20]](#footnote-21) Regional resources were economically dispatched in the simulations to respect the assumed “normal” transmission system transfer limits.[[21]](#footnote-22) The amount of resources assumed for each scenario was adequate to meet the systemwide energy requirements.

## Assumptions

This section summarizes the key assumptions made for the following parameters:

* Unconstrained and constrained transmission
* Interchanges with neighboring systems
* Weather year
* Energy storage and electrification load assumptions
* Resource threshold prices ($/MWh)

### Parameters for Unconstrained and Constrained Transmission Simulations

Production costs were simulated and analyzed under unconstrained and constrained conditions. Under unconstrained transmission, the New England transmission system was modeled as a single-bus system. Under constrained transmission scenarios, the system was modeled using the “pipe” and Regional System Plan (RSP) “bubble” configuration, with “pipes” representing transmission interfaces that connect the “bubbles,” which represent the various RSP subareas.[[22]](#footnote-23) See Figure 4‑1.



Figure 4‑1: Assumed New England system representation for the 2030 study year.(a)

**Notes:** BHE = Northeastern Maine; CMA/NEMA = Central Massachusetts/Northeast Massachusetts; CSC = Cross-Sound Cable; CT = Connecticut; NB = New Brunswick, Canada; NE = New England; NH = New Hampshire; NOR = Norwalk; NY = New York; SEMA/RI = Southeast Massachusetts/Rhode Island; SME = Southern Maine; Southeast Massachusetts; SWCT = Southwest Massachusetts; OSW = offshore wind; VT = Vermont; WMA = Western Massachusetts. Refer to the System Planning Subareas map at this ISO link: <https://www.iso-ne.com/about/key-stats/maps-and-diagrams/>.

(a) The ratings are a function of unit availabilities, area loads, or both.

### Interchanges with Neighboring Systems

Table 4‑1 shows the assumed 2030 external interchanges with neighboring systems, including the new state-contracted transmission line from Québec (i.e., the NECEC). The same internal and external interface capabilities were assumed for all scenarios. Historical profiles were used to reflect both FCM capacity imports and opportunity-based energy imports that respected the import-transfer capability of the ties.

Table 4‑1  
Interchange with Neighboring Systems (MW)

|  |  |  |
| --- | --- | --- |
| **Interconnection** | **Import-Transfer Capability (MW)(a)** | **Interchange Modeling** |
| **Highgate** | 217(b) | Historical diurnal profile averaged over 2016 through 2018 |
| **Hydro-Québec (HQ) Phase II** | 2,000(b) | Historical diurnal profile averaged over 2016 through 2018 |
| **HQ-NECEC** | 1,200 | Assumed firm energy delivery of 1,090 MW across all hours |
| **New Brunswick** | 1,000(b) | Historical diurnal profile averaged over 2016 through 2018 |
| **New York AC** | 1,400(b) | Assume no interchange(c) |
| **CSC** | 330(b) | Assume no interchange(c) |

(a) A zero CO2 emissions rate was assumed for net imports in this study.

(b) These values represent import capability for energy.

(c) Assuming no interchange allows a straight comparison of the regional production cost across all scenarios.

### Weather-Year Assumptions

For all scenarios, 2015 wind, solar, and load profiles (scaled to 2030) were used. The use of different weather-year profiles can result in different magnitudes for the study metrics, but broad results would be similar.

### Energy Storage and Electrification Load Assumptions

For all scenarios, the ISO’s 2019 CELT Report was the basis for demand assumptions, and projected loads for 2028 were increased to represent 2030 using the growth rate from 2027 to 2028 (see Table 3‑1).

Energy storage (i.e., pumped storage and batteries) are used to level the load, net of dispatchable resources. Across all scenarios, existing pumped-storage units were dispatched to minimize the range of daily high and low net loads given the physical and economic constraints of the storage resources such as losses. The net loads reflect adjustments to account for all energy efficiency, active demand resources, all photovoltaic (behind-the-meter [BTM] and non-BTM), plug-in hybrid electric vehicles (PHEVs), wind energy, hydro (excluding pumped storage), existing imports, and new imports. This treatment of pumped storage was assumed to have approximately 74% efficiency.

Battery storage was assumed to have approximately 90% efficiency. The batteries were assumed to have enough storage to discharge at full output for four hours. For the electrification scenario, Anbaric did not specify locations of battery storage; therefore, the ISO assumed battery storage was evenly distributed across the RSP subareas. For the 0 MW (reference), 8000, 10000, and 12000 scenarios, 150 MW of batteries were added to each RSP subarea, except for the SWCT subarea, where 200 MW of batteries were added, for a total of 2,000 MW of batteries. The NEMA and WMA RSP subareas included the colocated battery storage interconnecting into the distribution system.

A consumption profile representing additional heat-pump load was developed based on the difference between the observed historical weather-affected hourly loads and an average diurnal load profile for the month of April. This average diurnal load profile was assumed to represent a weather-neutral day. When the observed loads were higher than the weather-neutral day, heat-pump operation was assumed, and when the observed loads were lower than the weather-neutral day, heat pumps were assumed inactive. This captured, from a broad perspective, the effect of increased heating loads during the colder hours of the heating season when the temperatures were low. No heat-pump operation was assumed during the months of May through September.

The characteristics for PHEVs were based on statistics from the National Renewable Energy Laboratory’s (NREL) EVI-Pro projection tool.[[23]](#footnote-24) Historical data suggested that PHEV charging tends to start in the later part of the day and continue into the night. See Figure 4‑2.



Figure 4‑2: Annual average daily charging profile (13.2 kilowatt-hour [kWh] per vehicle per day).

### Resource Threshold Prices

Threshold prices were assigned to profile-based resource types in this study, including photovoltaics (PV), onshore wind, and offshore wind, to facilitate the analysis of load levels where the amount of $0/MWh resources exceeded the system load, which leads to oversupply.[[24]](#footnote-25) The threshold prices govern which type of resources to back down first to balance supply and demand and inform the model about which resources’ output to reduce—or “spill.” Threshold prices are not necessarily indicative of actual costs, expected bidding behavior, or the preference for one type of resource over another. The 2019 Anbaric Economic Study used similar threshold prices as in prior economic studies (2016 and 2017), with two adjustments. First, the behind-the-meter PV and utility-scale PV (FCM and energy only) were differentiated. Second, a preferential threshold price was applied to energy from the newly proposed NECEC tie line, considering publicly available contract terms.[[25]](#footnote-26) The use of different threshold prices other than indicated in Table 4‑2 may produce different outcomes.

Table 4‑2  
Threshold Prices for the 2019 Anbaric Economic Study ($/MWh)

|  |  |
| --- | --- |
| **Price-Taking Resource** | **Threshold Price ($/MWh)** |
| **Behind-the-meter PV** | 1 |
| **NECEC (1,090 MW)** | 2  11 (sensitivity)(a) |
| **Utility-scale PV** | 3 |
| **Onshore/offshore wind** | 4 |
| **New England hydro** | 4.5 |
| **Imports from HydroQuébec, including Highgate and Phase II** | 5 |
| **Imports from New Brunswick** | 10 |

1. Under base case assumptions of NECEC at $2/MWh, NB imports, HQ imports, New England hydro, and utility-scale PV would be curtailed before curtailing NECEC. A set of NECEC sensitivity scenarios were performed assuming a higher threshold price of $11/MWh for NECEC that would result in curtailing NECEC energy first before curtailing other resources.

# Key Observations

The 2019 Anbaric Economic Study considered the impacts of addition of 8,000 MW to 12,000 MW of offshore wind interconnecting to New England balancing authority area in southern New England and the Boston area, given the current transmission system.[[26]](#footnote-27) The offshore wind amounts added into each scenario of the study included 2,300 MW of offshore wind resources under development with a state contract to build. A reference case with no new offshore wind additions was added to facilitate meaningful comparisons between the other scenarios and the current system.

The most relevant simulation results are included in this report.[[27]](#footnote-28) All offshore integration scenarios produced similar results, directionally, for the various amounts of offshore wind interconnected, the interconnection areas under review, and the generator dispatch assumptions described. When considered as a whole, the results for the four scenarios and a sensitivity analysis varying threshold prices provide useful information, as follows:

* The significant potential for spilling offshore wind energy
* Directionally relevant cost estimates and production cost and LSE energy expense (LSEEE) impacts
* Affects to air emissions, specifically CO2 emissions
* The impacts of developing offshore wind resources on transmission congestion

This report highlights the most significant results of the 2019 Anbaric Economic Study. Results of scenarios that included a higher threshold price (see Section 4.2.5) for the energy from the state-contracted NECEC new transmission line did not yield significantly different results. Table 5‑1 summarizes the outputs from the metrics assessed for each scenario.

Table 5‑1  
Summary of Scenario Outputs

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Metric** | **Scenario** | | | | |
| **0** | **8000** | **10000** | **12000** | **10000\_Sen** |
| **LMP ($/MWh)** | 43.0 | 27.0 | 23.9 | 21.4 | 26.1 |
| **Production costs ($ million)** | 2,412 | 1,274 | 1,179 | 1,094 | 1,286 |
| **LSEEE ($ million)** | 6,504 | 4,086 | 3,614 | 3,228 | 3,945 |
| **Spillage (TWh)** | 2.4 | 9.6 | 15.1 | 21.3 | 12.4 |
| **CO2 emissions (million short tons)** | 33.7 | 22.1 | 21.0 | 19.9 | 22.1 |

The following sections discuss in detail the observations from the simulation outputs.

## Oversupply (Spillage)

Spilled energy occurs when resource production exceeds the system’s ability to use the power, whether to protect transmission security or due to the lack of demand for the power when produced. The large-scale development of remote resources, such as offshore wind or onshore wind in northern Maine, may require transmission additions to avoid transmission-related spillage. Conversely, the development of resources near load centers in southern New England and Boston helps avoid transmission-related spillage of renewable energy.

For all scenarios studied, the2019 Anbaric Economic Study confirmed that high penetrations of offshore wind results in oversupply. Additionally, increased demand due to increased electrification was not enough to eliminate spillage because the demand from heat pumps and electric vehicles does not consistently align with offshore wind production. Study results indicate that the assumed amount of electrification in conjunction with an increase in battery storage, as proposed by Anbaric in the 10000 Sen scenario, would help lower the offshore wind spillage by 1.15 terawatt-hours (TWh), which is 23% of the total offshore wind resource spillage. To reduce the spillage of renewables, the interconnection of resources close to load centers is preferred (i.e., Mystic substation, Boston MA).

The rate of spillage increases as offshore wind buildout increases under the study’s assumptions.[[28]](#footnote-29) Most spillage is attributed to oversupply when loads are lower. Figure 5‑1 highlights the spillage for all scenarios studied.



Figure 5‑1: Total amount of spilled resource energy (terawatt-hours; TWh) by scenario studied.

Note: C refers to constrained, and UC refers to unconstrained.

Increasing the NECEC threshold price to $11/MWh results in significant spillage of NECEC while spillage of hydro, wind, and existing imports decreases. Yet, total spillage remains the same regardless of NECEC threshold-price sensitivity.

Total spillage of offshore wind and hydro is 3.44 TWh in the Anbaric 8,000 MW scenario. Study results revealed spillage varies *significantly* by month, from 0.09 TWh in August to 1.74 TWh in April. See Figure 5‑2. The *least* amount of spillage in the 8,000 MW constrained scenario occurred in the summer months of July and August when demand is generally high.[[29]](#footnote-30) The *most* spillage in the 8,000 MW constrained scenario occurred in April due to high wind production and low demand. Looking more closely at the April results shows that wind production was sizable, supporting the premise that spillage is due to oversupply at times of lower loads.



Figure 5‑2: Monthly spilled resource energy (TWh) for the 8,000 MW constrained scenario.

Examining spillage on July 2, 2030, from the 8,000 MW scenario revealed an offshore wind output profile almost opposite of the load curve. See Figure 5‑3. High offshore wind output was observed at night when the loads were low, and during the day when demand was high, offshore wind output was low and little to no spillage of renewable resources occurred.



Figure 5‑3: Spillage on a low-wind summer day, July 2, 2030 (MW).

Offshore wind interconnected into the SEMA and RI subareas was spilled due to either a constrained SEMA/RI export interface or a systemwide energy oversupply. Increased electrification loads and batteries in the Anbaric 10000\_Sen scenario reduced the amount of offshore wind spilled due to constrained transmission by 0.17 TWh, which was approximately 10.1% of the total offshore wind spilled due to congestion of the SEMA/RI export interface in this scenario.[[30]](#footnote-31) Figure 5‑4 shows how much offshore wind was spilled due to transmission constraints compared with oversupply for the Anbaric 10000 and Anbaric 10000\_Sen scenarios, respectively.

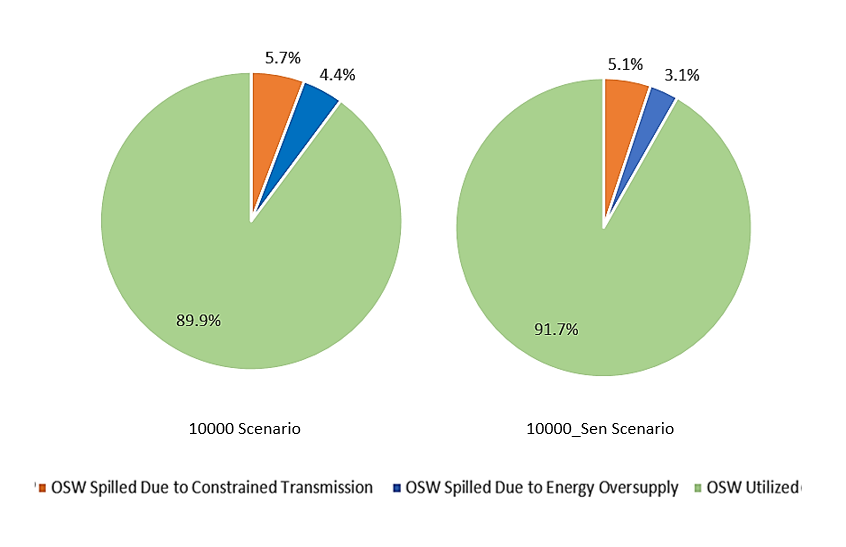


Figure 5‑4: Spilled offshore wind for the Anbaric 10000 and 10000\_Sen scenarios, constrained transmission.

## Systemwide Production Costs

Production costs reflect operating costs (which account for fuel-related costs), dispatch and unit commitment, and emission allowances. Natural gas consumption, and to a lesser extent other fossil fuels, drive production costs.

In general, as offshore wind energy increases across the scenarios, production costs decrease, as shown in Figure 5‑5.The addition of 8,000 MW offshore wind decreases systemwide production costs to approximately half the reference scenario (0 MW of new offshore wind). However, the additional production costs savings are less than $100 million for each 2,000 MW increment of offshore wind above 8,000 MW, as seen in the 10,000 MW and 12,000 MW offshore wind scenarios.



Figure 5‑5: Systemwide production costs ($ million).

Table 5‑2 illustrates the system terawatt-hour production by fuel type for the unconstrained and constrained systems for the 2030 study year (refer to Section 4.2.1).[[31]](#footnote-32)

Table 5‑2  
Total Systemwide Production by Fuel Type (TWh)   
Constrained (Cstr.) and Unconstrained (Uncstr.) Transmission

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Fuel Type** | **Scenario** | | | | | | | | | |
| **0** | | **8000** | | **10000** | | **10000\_Sen** | | **12000** | |
| **Cstr.** | **Uncstr.** | **Cstr.** | **Uncstr.** | **Cstr.** | **Uncstr.** | **Cstr.** | **Uncstr.** | **Cstr.** | **Uncstr.** |
| **Offshore wind** | 0.12 | 0.12 | 30.41 | 30.42 | 34.71 | 35.29 | 35.86 | 36.45 | 39.02 | 39.18 |
| **Onshore wind** | 3.71 | 3.71 | 3.67 | 3.67 | 3.63 | 3.62 | 3.65 | 3.64 | 3.61 | 3.59 |
| **Natural gas** | 46.25 | 44.05 | 23.30 | 22.43 | 21.31 | 20.54 | 23.41 | 22.65 | 19.52 | 18.95 |
| **Oil** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Imports** | 24.64 | 27.00 | 20.86 | 21.87 | 19.55 | 20.17 | 20.61 | 21.16 | 18.31 | 18.92 |
| **Coal** | 0.64 | 0.52 | 0.16 | 0.09 | 0.14 | 0.06 | 0.20 | 0.14 | 0.12 | 0.07 |
| **Landfill gas/ municipal solid waste** | 4.17 | 4.08 | 3.16 | 3.09 | 2.94 | 2.89 | 3.06 | 3.03 | 2.76 | 2.72 |
| **Photovoltaics** | 9.47 | 9.47 | 9.47 | 9.47 | 9.47 | 9.47 | 9.47 | 9.47 | 9.47 | 9.47 |
| **Wood** | 4.72 | 4.71 | 4.70 | 4.70 | 4.70 | 4.70 | 4.70 | 4.70 | 4.70 | 4.70 |
| **Nuclear** | 12.33 | 12.33 | 12.33 | 12.33 | 12.33 | 12.33 | 12.33 | 12.33 | 12.33 | 12.33 |
| **Energy efficiency/ demand response** | 36.09 | 36.09 | 36.09 | 36.09 | 36.09 | 36.09 | 36.09 | 36.09 | 36.09 | 36.09 |
| **Hydroelectric** | 9.20 | 9.25 | 7.40 | 7.42 | 6.69 | 6.41 | 7.14 | 6.86 | 5.62 | 5.55 |

## Annual Average Locational Marginal Prices

The impact of additional offshore wind was observed through evaluating average locational marginal prices (LMPs) for selected RSP subareas, under constrained and unconstrained scenarios of the 2030 study year. The scenarios analyzed for the unconstrained cases show lower average systemwide LMPs as the amount of offshore wind increases because these price-taking resources produce greater amounts of energy. The reduced LMPs occur when the offshore wind displaces less efficient fossil fuel generating resources and sometime set the LMP at their lower threshold price. When SEMA/RI exports are constrained by transmission limits, the LMPs for Greater New England are higher and affect a large fraction of New England’s load while the LMPs are lower within the SEMA/RI constrained subarea, which affects a small fraction of New England’s load.

Constraints on the Surowiec South interface cause price separation. The added demand associated with electrification (as illustrated in the 10000\_Sen scenario) increases LMPs. In the unconstrained cases, price-taking resources produce more energy, therefore resulting in slightly lower LMPs for the SME, NH, and Boston subareas. As illustrated in Figure 5‑6, the reference scenario has the largest price separation between BHE/ME and the rest of the system. Price separation is persistent but decreased as more offshore wind is added, which lowers the LMPs outside Maine.



Figure 5‑6: Annual average LMPs by RSP subarea for constrained and unconstrained cases ($/MWh).

## Load-Serving Entity Energy Expense and Uplift Costs

Load-serving entities represent organizations that directly serve retail electricity customers. Risk management is particularity important to LSEs because they are sensitive to and may not be able to hedge against sudden or unexpected price variations that could affect their customers. Figure 5‑7 shows load-serving entity energy expenses and “uplift” costs (i.e., make-whole payments) for all constrained and unconstrained cases. This metric provides insight into one of the key costs borne by New England consumers. The decrease in LSE energy expense with high levels of offshore wind is a much larger magnitude than the reduction in production costs.



Figure 5‑7: Load-serving entity energy expenses and uplift costs ($ million), constrained and unconstrained ($ million).

LSE energy expenses and uplift costs decrease by approximately one-third with the addition of 8,000 MW offshore wind from the reference scenario**.** Incremental savings of LSE energy expenses are lower when more than 8,000 MW of offshore wind is interconnected. Uplift increases slightly as wind penetration reduces LMPs and resources needed for reserves and system security require additional supplemental payments to cover their operating costs.

## Native New England Resource CO2 Emissions

The results for the metrics that assessed the environmental impacts associated with the different scenarios provide some insight on future emission trends. The total CO2 emissions associated with the different scenarios are directly associated with the type and amount of fossil fuels the different scenarios use to generate electricity.

The addition of 8,000 MW offshore wind reduces by more than one-third the region’s carbon dioxide emissions from electric power generators compared with the reference scenario. CO2 emissions from the 10000\_Sen scenario increase to levels comparable to the 8,000 MW offshore wind scenario because more energy production from natural-gas-fired units is required to meet the additional demand associated with electrification, given the assumed interconnection points in the study and other assumptions. CO2 emissions reduce only minimally with the increase from 8,000 MW to 12,000 MW of offshore wind and resulting oversupply. Because a portion of the additional 4,000 MW is spilled and does not serve load, it does not contribute to reducing CO2 emissions. Figure 5‑8 illustrates the decrease in CO2 emissions.



Figure 5‑8: Native New England resource CO2 emissions, constrained and unconstrained cases (millions of short tons).

## Congestion by Interface

Locating large amounts of new resources with relatively low production costs (i.e., offshore wind) into largely one area of the system—in this case, southeastern New England—instead of close to load centers increases congestion. Therefore, when utilizing interconnections largely into one area, offshore wind additions in excess of 8,000 MW results in the need for transmission expansion to avoid spillage and maximize the use of offshore wind.[[32]](#footnote-33) The SEMA/RI export interface is congested in the 8,000 to 12,000 MW scenarios because more offshore wind generation is required to serve load outside of the SEMA and RI areas with the assumed nuclear retirements. The Surowiec South interface is also heavily constrained due to the assumed interface limit binding with the addition of NECEC.[[33]](#footnote-34) The results for all the other scenarios show no transmission constraints, as illustrated in Figure 5‑9. As noted in the 10000\_Sen scenario, electrification adds approximately 5 TWh of demand annually. Although spillage may be reduced, the demand from heat pumps and electric vehicles may cause more frequent congestion of the SEMA/RI export interface, depending on the alignment of these loads with offshore wind production, because of lower-cost generation located in the this zone.



Figure 5‑9: Congestion by interface (hours) for the constrained cases.

The SEMA/RI export interface is congested more frequently with the addition of 1,500 MW of offshore wind inside the interface (500 MW added to Kent County, and 1,000 MW added to Brayton Point) associated with the 10,000 MW and 12,000 MW of offshore wind, with congestion ranging from 93 to 1,478 hours per year. This congestion occurs most often in the winter months, followed by the shoulder months. The SEMA/RI interface is least congested in the summer months due to the higher local energy consumption. Figure 5‑10 provides a representation of monthly congestion for the SEMA/RI interface for all scenarios studied.



Figure 5‑10: SEMA/RI export interface congestion by month (% of time the interface is at its limit).

# Summary

This section summarizes the results of the 2019 Anbaric Economic Study, which assessed the effects of different offshore wind-expansion scenarios on the future electric power system in New England. The results for four scenarios and threshold-price sensitives provide useful information when considered holistically because results of this study show a modest economic benefit for increasing offshore wind additions above 8,000 MW. All offshore-integration scenarios produced directionally similar results. Key observations of the 2019 Anbaric Economic Study include the following:

* The reduction of systemwide production costs by one-half with 8,000 MW of offshore wind
* The reduction of carbon dioxide emissions by one-third with 8,000 MW of offshore wind
* The significant potential for spilling offshore wind energy, if interconnections are largely in the SEMA/RI area and not made directly to load centers
* Increased congestion of the SEMA/RI interface

The results revealed that spillage is significant for each of the various amounts of offshore wind interconnected to points in southern New England, with the rate of spillage increasing as the offshore wind buildout increases. Production cost analysis reveals that, in this configuration, the environmental benefits of the addition of 12,000 MW of offshore wind may not be realized because the wind cannot serve load due to transmission constraints. As illustrated in the 8,000 MW scenario, spillage varies *significantly* by month from 0.09 TWh in August to 1.74 TWh in April. Offshore wind may not be able to serve increases in demand due to electrification (approximately 5 TWh annually total) because of differences in the timing of when wind energy is available and added electrification load occurs. Study results indicate that the use of additional battery storage as proposed by Anbaric would help lower offshore wind spillage. While offshore wind continues to oversupply in shoulder seasons, it does not provide a steady supply in the high-demand months of July and August.

Increased congestion of the SEMA/RI interface can be alleviated by interconnection to load centers in Connecticut and Massachusetts. The SEMA/RI export interface is congested in the 8,000 MW to 12,000 MW scenarios because more offshore wind generation is required to serve load outside the SEMA and RI areas with the assumed nuclear retirements.

The addition of 8,000 MW of offshore wind decreases systemwide production costs to approximately half the reference scenario (0 MW of new offshore wind). However, the incremental savings in production costs are less than $100 million per each 2,000 MW of additional offshore wind, as seen in the 10,000 MW and 12,000 MW offshore wind scenarios.

The study of the environmental impacts associated with different levels of offshore wind additions provides insight on future emission trends. The total CO2 emissions associated with the different scenarios analyzed in this study are tied directly to the type and amount of fossil fuel resources modeled and account for renewables displacing fossil fuel resources. Offshore wind additions reduce the New England carbon footprint but are weather dependent, which may result in an inability to consistently meet demand. The consideration of transmission enhancements, storage, or both may be helpful in utilizing offshore wind more effectively Study results showed a reduction in CO2 emissions by approximately one-third in all offshore wind scenarios compared with the reference scenario. However, CO2 emissions of the Anbaric 10000\_Sen scenario are slightly higher because more energy production from natural-gas-fired units is required to meet the additional demand associated with electrification.

1. ISO New England, *2019 Economic Study: Offshore Wind Integration* (June 30, 2020), <https://www.iso-ne.com/static-assets/documents/2020/06/2019_nescoe_economic_study_final.docx>. [↑](#footnote-ref-2)
2. Refer to figure 6-13 in the NESCOE Economic Study; see above citation. [↑](#footnote-ref-3)
3. Theodore Paradise (sr. vice president, Transmission Strategy and Counsel, Anbaric Development Partners, LLC), “2019 ISO New England Economic Study Request for Offshore Wind Impacts,” letter to Peter Bernard (chair, ISO New England Inc. Planning Advisory Committee) (April 1, 2019), <https://www.iso-ne.com/static-assets/documents/2019/04/anbaric_2019_economic_study_request.pdf>. [↑](#footnote-ref-4)
4. The RENEW Economic Study requested the ISO to study the economic impact of conceptual increases in hourly operating limits on the Orrington-South interface from conceptual transmission upgrades. RENEW Northeast, *Proposal for Economic Study of Orrington-South Interface*, PAC presentation (April 25, 2019), <https://www.iso-ne.com/static-assets/documents/2019/04/a2_renew_2019_economic_study_request_presentation.pdf>. The NESCOE 2019 Economic Study examined transmission system and wholesale market impacts associated with the increasing penetration of incremental offshore wind resources strategically placed in southern New England. NESCOE, *Offshore Wind Integration*, PAC presentation (April 25, 2019), <https://www.iso-ne.com/static-assets/documents/2019/04/a2_nescoe_2019_economic_study_request_presentation.pptx>. Also see, ISO New England, *2019 Economic Study: Offshore Wind Integration*, final report (June 30, 2020), <https://www.iso-ne.com/static-assets/documents/2020/06/2019_nescoe_economic_study_final.docx>. [↑](#footnote-ref-5)
5. ISO New England, *ISO New England Inc. Transmission, Markets, and Services Tariff* (ISO tariff), Section II, *Open Access Transmission Tariff*, Attachment K, “Regional System Planning Process” (January 22, 2020), <https://www.iso-ne.com/static-assets/documents/regulatory/tariff/sect_2/oatt/sect_ii.pdf>. [↑](#footnote-ref-6)
6. *Load-serving entity (LSE) energy expenses* are the costs the LSEs pay for the energy at the receipt point’s calculated locational marginal price (LMP). They equal the total electric energy revenues that resources and imports from neighboring systems would receive for supplying electric energy to the wholesale market plus the cost of congestion. [↑](#footnote-ref-7)
7. OATT, Attachment K, Section 4.1b. [↑](#footnote-ref-8)
8. This tool was developed to evaluate the reliability impacts of Forward Capacity Market (FCM) retirement delist bids, substitution auction demand bids, bilateral transactions, and all reconfiguration auction demand bids on system fuel security, as required by Section III.13.2.5.2.5A of the ISO tariff for the 2022-23 and 2023-24 capacity commitment periods. See: Robert Ethier (vice president, System Planning, ISO New England), “Regarding 2019 Economic Study Request,” memo to Theodore Paradise (sr. vice president, Transmission Strategy and Counsel) (February 13, 2020), <https://www.iso-ne.com/static-assets/documents/2020/02/2019_anbaric_econ_study_request.pdf>; and ISO tariff, Section III.13.2.5.2.5A (August 1, 2020), <https://www.iso-ne.com/static-assets/documents/regulatory/tariff/sect_3/mr1_sec_13_14.pdf>. [↑](#footnote-ref-9)
9. ISO New England, *ANBARIC 2019 Economic Study—Offshore Wind Results*, PAC presentation (March 18, 2020), <https://www.iso-ne.com/static-assets/documents/2020/03/a8_anbaric_2019_economic_study_prelim_results_marpac.pdf>, and *Anbaric 2019 Economic Study—Follow-Up to the March 2020 PAC Meeting,* PAC presentation (May 20, 2020), <https://www.iso-ne.com/static-assets/documents/2020/05/a6_anbaric_2019_economic_study_follow_up_to_march_2020_pac_meeting.pdf>. [↑](#footnote-ref-10)
10. ISO New England, *Energy Storage Modeling in 2019 Anbaric Study—Follow-Up to the May 2020 PAC Meeting*, PAC presentation (June 17, 2020), <https://www.iso-ne.com/static-assets/documents/2020/07/energy_storage_in_2019_anbaric_study_june_2020_pac.pdf>. [↑](#footnote-ref-11)
11. Information on how to access Critical Energy Infrastructure Information (CEII) materials is available at the ISO’s “Request Data and Information,” webpage (2020), <https://www.iso-ne.com/participate/support/request-information>. [↑](#footnote-ref-12)
12. The ISO determined optimal interconnection points early in the study process, which it presented to stakeholders at the May 21, 2019, PAC meeting; see *2019 Economic Studies,* <https://www.iso-ne.com/static-assets/documents/2019/05/a2_2019_economic_study_draft_scope_of_work_and_high_level_assumptions.pptx>. The study assumed that these interconnections would need a combination of 345 kV reinforcements and expansion and that not all the 8,000 MW of offshore wind would be able to operate simultaneously at nameplate levels. [↑](#footnote-ref-13)
13. “Transmission Service Agreement Unitil—12.317 MW) by and between Central Maine Power Company, as Owner, And H.Q. Energy Services (U.S.) INC., as Purchaser,” (June 13, 2018), <https://www.sec.gov/Archives/edgar/data/1634997/000156459018018891/agr-ex106_142.htm>. [↑](#footnote-ref-14)
14. Refer to footnote 4; see Figure 6-13 in the NESCOE study. [↑](#footnote-ref-15)
15. The 29 MW Block Island offshore wind resource was considered an existing resource for this study. [↑](#footnote-ref-16)
16. The ISO New England Interconnection Request Queue lists the status of requests for the interconnection of new or uprated (increased capacity) generating facilities in New England, including elective transmission upgrades (ETUs) and transmission service requests; see <https://www.iso-ne.com/system-planning/transmission-planning/interconnection-request-queue/> and <https://irtt.iso-ne.com/reports/external>.

    The interconnection process is described in Schedule 22, *Large Generator Interconnection Procedures* (LGIP) (<https://www.iso-ne.com/static-assets/documents/regulatory/tariff/sect_2/sch22/sch_22_lgip.pdf>), Schedule 23, *Small Generator Interconnection Procedures* (SGIP) (<https://www.iso-ne.com/static-assets/documents/regulatory/tariff/sect_2/sch23/sch_23_sgip.pdf>), and Schedule 25, *Elective Transmission Upgrade Interconnection Procedures* (ETU) (<https://www.iso-ne.com/static-assets/documents/2015/02/sch_25.pdf>). [↑](#footnote-ref-17)
17. ISO New England, PAC presentations, *2019 Economic Studies—Draft Scope of Work and High-Level Assumptions* (May 21, 2019), <https://www.iso-ne.com/static-assets/documents/2019/05/a2_2019_economic_study_draft_scope_of_work_and_high_level_assumptions.pptx>; *2019 Economic Studies—Detailed Assumptions* (August 8, 2019), <https://www.iso-ne.com/static-assets/documents/2019/08/a8_2019_economic_studies_detailed_assumptions.pptx>. [↑](#footnote-ref-18)
18. ISO New England, *2019 Economic Study Requests Status Update*, PAC presentation (November 20, 2019), <https://www.iso-ne.com/static-assets/documents/2019/11/a6_2019_economic_study_request_status_update.pdf>. [↑](#footnote-ref-19)
19. GridView is not a power-flow model; refer to Section 5.2.1 for more details. [↑](#footnote-ref-20)
20. Detailed transmission interface limits for 2025 used for this study are available in the ISO’s PAC presentation, *Forward Capacity Auction 14 Transmission Transfer Capabilities and Capacity Zone Development* (March 21, 2019), slide 25, <https://www.iso-ne.com/static-assets/documents/2019/03/a8_fca14_transmission_transfer_capabilities_and_capacity_zone_development.pdf>. [↑](#footnote-ref-21)
21. Normal transmission system transfer limits account for transmission system security constraints, which consider expected transmission facilities in service and first-contingency(N-1) criteria. A *first contingency* isthe loss of the power system element (facility) with the largest impact on system reliability. A *second contingency* (N-1-1) occurs after a first contingency when the facility that, at that time, has the largest impact on the system is lost. N-1-1 also can refer to a constraint met by maintaining an operating reserve that can increase output when the first contingency occurs. [↑](#footnote-ref-22)
22. For more information on RSP areas, refer to the “System Planning Subareas” map at this ISO website link: <https://www.iso-ne.com/about/key-stats/maps-and-diagrams/#system-planning-subareas>. Also refer to the ISO’s “Regional System Plan” webpage at: <https://www.iso-ne.com/system-planning/system-plans-studies/rsp/>. [↑](#footnote-ref-23)
23. NREL, “EVI-Pro Lite Tool Paves the Way for Future Electric Vehicle Infrastructure Planning,” website article (May 16, 2018), <https://www.nrel.gov/news/program/2018/nrels-evi-pro-lite-tool-paves-the-way-for-future-electric-vehicle-infrastructure-planning.html>. [↑](#footnote-ref-24)
24. Although offshore wind resources were modeled as price-taking resources in this study due to their threshold price of $0/MWh, these resources do exhibit some flexibility if they are “held-back” for reserves or operated under do-not-exceed dispatch (DNE) provisions. The DNE methodology sets an upper limit of how much generation the system can accommodate from an intermittent power resource. The resource may operate freely between 0 MW and this limit but must not exceed it. This helps maximize the amount of intermittent generation on the system by accommodating the variable nature of these resources’ fuel. [↑](#footnote-ref-25)
25. Petition of Massachusetts Electric Company and Nantucket Electric Company, each d/b/a National Grid for approval by the [Massachusetts] Department of Public Utilities (DPU) of a long-term contract for procurement of Clean Energy Generation, pursuant to Section 83D of *An Act Relative to Green Communities*, St. 2008, c. 169, as amended by St. 2016, c. 188, § 12, DPU 18-64; DPU 18-65; with three Power Purchase Agreements for firm qualified clean energy from hydroelectric generation and between the following parties and H.Q. Energy Services (US) Inc. as of June 13, 2018: (1) NSTAR Electric Co. d/b/a Eversource Energy (US) Inc., Exhibit JU-3-A Page 1 of 87, revised October 17, 2018 (<https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/9946888>); (2) Massachusetts Electric Company and Nantucket Electric Company d/b/a National Grid, redacted DPU 18-64/18-65/18-66, October 17, 2018, Exhibit JU-3-B, Page 1 of 97 (<https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/9946889>); and (3) Fitchburg Gas and Electric Light Co. d/b/a Unitil DPU 18-64/18-65/18-66, revised October 17, 2018, Exhibit JU-3-C, Page 1 of 85 (<https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/9946890>). Docket (accessed June 22, 2020): <https://eeaonline.eea.state.ma.us/DPU/Fileroom/dockets/bynumber/18-65>. [↑](#footnote-ref-26)
26. Transmission system upgrades to accommodate 8,000 MW or more of offshore wind were discussed in the NESCOE 2019 Economic Study (Section 6.1.9.), for which the ISO determined that approximately 7,000 MW of new offshore wind (5,800 MW connected to the southern shore substations and 1,200 MW connected to Mystic) has the potential to be interconnected without major additional 345 kV reinforcements. [↑](#footnote-ref-27)
27. Additional results are included in the ISO’s PAC presentations from December 19, 2019, and January 23, February 20, April 23, and May 20, 2020. Transmission interconnection results are summarized in the April 23 and May 20, 2020, PAC presentations. See: **(1)** *2019 Economic Study—Preliminary NESCOE Results* (December 19, 2019), <https://www.iso-ne.com/static-assets/documents/2019/12/a3_2019_economic_study_preliminary_nescoe_results.pdf>; **(2)** *2019 Economic Study—Follow-Up to the December 2019 Meetin*g (January 23, 2020), <https://www.iso-ne.com/static-assets/documents/2020/01/a4_jan_2020_economic_study_qa_final-67f4425e.pdf>; **(3)** *NESCOE 2019 Economic Study—8,000 MW Offshore Wind Results* (February 20, 2020), <https://www.iso-ne.com/static-assets/documents/2020/02/a6_nescoe_2019_Econ_8000.pdf>; **(4)** *2019 NESCOE Economic Study—Follow-Up to the February 2020 Meeting* (April 23, 2020), <https://www.iso-ne.com/static-assets/documents/2020/04/a5-nescoe-2019-econ-study-follow-to-the-feb-2019.pdf>. **(5)** *2019 Economic Study Offshore Wind Transmission Interconnection Analysis* (May 20, 2020), <https://smd.iso-ne.com/operations-services/ceii/pac/2020/05/a3_2019_economic_study_offshore_wind_transmission_interconnection_analysis_ceii.pdf>. [↑](#footnote-ref-28)
28. As discussed in Section4.2.5, threshold prices drive the curtailment of specific resources and the order of the spilled resources; the prices do not reflect actual expectations of market outcomes. The 2019 Anbaric Economic Study used the 2015 weather year to shape the 2030 wind, solar, and load profiles (see Section 4.2.4). If a different weather year were used, the results would differ. [↑](#footnote-ref-29)
29. As a general trend, offshore wind patterns vary when wind production is highest in the shoulder months and lower during the peak months. [↑](#footnote-ref-30)
30. Electrification and additional batteries across New England, plus additional flexibility to redirect offshore wind delivery outside the constrained SEMA/RI interface via interconnections to Mystic substation (Boston, MA) and Montville substation (Montville, CT), reduced total spillage by 1.15 TWh, even though the SEMA/RI interface was constrained 186 hours more. [↑](#footnote-ref-31)
31. Natural gas, offshore wind, imports, and hydro resources are the primary fuel types supplying electrification demand (heat pumps and electric vehicles). [↑](#footnote-ref-32)
32. As part of the 2019 NESCOE Economic Study, the ISO developed future interconnection scenarios for offshore wind and identified the approximate megawatt quantities of inverter-based resources (e.g., offshore wind) that could interconnect without major transmission upgrades beyond these local points. The ISO determined that with the expected transmission topology for the 2030 study year, approximately 7,000 MW of new offshore wind (5,800 MW connected to the southern shore substations and 1,200 MW connected to Mystic) has the potential to be interconnected without major additional 345 kV reinforcements. See 2019 NESCOE Economic Study report, Section 6.1.9, <https://www.iso-ne.com/static-assets/documents/2020/06/2019_nescoe_economic_study_final.docx>. [↑](#footnote-ref-33)
33. This study assumed a Surowiec South interface transfer limit of 1,500 MW. However, the Surowiec South interface transfer limit is expected to increase to 2,500 MW once NECEC and its associated transmission upgrades are in service. [↑](#footnote-ref-34)