UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Modernizing Wholesale Electricity Market Design	**)))**	**Docket No. AD21-10-000**

REPORT OF ISO NEW ENGLAND INC.

Pursuant to the Federal Energy Regulatory Commission's ("Commission") Order Directing Reports issued on April 21, 2022 in the above-referenced docket, ISO New England Inc. ("ISO-NE" or the "ISO") respectfully submits the following responses to the questions that the Commission posed in the Order Directing Reports. For context, the Commission's questions are also included below (in italics, with footnotes omitted).

I. INTRODUCTION

As an initial matter, the ISO appreciates the Commission's focus on the changing resource mix, evolving customer electricity uses and future demand, and the relationship between those changes and the wholesale markets for electric energy and ancillary services. In New England, a combination of growing environmental concerns, historically low natural gas prices over the past decade, and continual technological change have led to the retirement of many nuclear, coal, and oil-fired generation resources, and the dominance of seasonally-constrained natural gas-fired generation in the region's resource mix.[1] At the same time, ambitious state policies support increasing renewable-energy generation resources in New

[1] 7,000 MW of generation has retired or announced retirement plans since 2013. *See* ISO New England Inc., 2022 Regional Electricity Outlook: On the Horizon, at (July 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/06/2022_reo.pdf.

England's resource mix, including substantial distributed energy ("behind-the-meter") generation resources.[2] Figure 1 summarizes the legislatively-mandated emission reduction goals of five of the six New England States.

Figure 1. New England Emission Reduction and Energy Decarbonization Goals

≥80% by 2050	Five states mandate greenhouse gas reductions economy wide: MA, CT, ME, RI, and VT (mostly below 1990 levels)
Net-Zero by 2050 80% by 2050	MA emissions requirement MA clean energy standard
90% by 2050	VT renewable energy requirement
100% by 2050 Carbon-Neutral by 2045	ME renewable energy goal ME emissions requirement
100% by 2040	CT zero-carbon electricity requirement
100% by 2030	RI renewable energy requirement

Achieving the states' emission reduction targets while maintaining a reliable regional power system will require proactive long-term planning efforts that place an enhanced focus on "four pillars" of New England's energy future: **Clean energy** resource investments to support a decarbonizing grid; a supply of flexible **balancing resources** needed to preserve reliability; assured input of energy sources to maintain **energy adequacy** of the region's power system; and continued **transmission investments** in order to convey new renewable-energy generation to load centers.[3] These four pillars of the decarbonized grid represent a logical evolution of

[2] Five of the six New England States have enacted legislation setting carbon dioxide emission reduction targets at levels of at least 80% below 1990 levels by 2050. New Hampshire does not have a legislatively enacted emission target.

[3] ISO New England Inc., 2022 Regional Electricity Outlook: On the Horizon, at 6-7 (July 2022) (identifying clean energy, balancing resources, energy adequacy, and robust transmission as the four pillars critical to development and

existing regional power system planning and operational objectives,[4] in light of the emission reduction targets of the New England States, the changing generation resource mix, and forecast long-term growth in regional electricity demand.

The changing resource mix and its many consequences have been the subject of extensive studies and stakeholder discussions in New England, as the ISO seeks to ensure the continued reliability of the grid moving forward. Key studies include: the Future Grid Pathways Study ("Pathways Study"),[5] the Future Grid Reliability Study,[6] the ongoing 2050 Transmission Study,[7] and work with the Electric Power Research Institute ("EPRI") to develop a framework for assessing energy adequacy risks associated with adverse weather events,[8] among other long-term planning efforts. Undertaken in collaboration with our state partners, and the New England Power Pool ("NEPOOL") stakeholders, the ISO believes these proactive efforts will leave the

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maintenance of a clean, decarbonized grid), *available at* https://www.iso-ne.com/static-assets/documents/2022/06/2022_reo.pdf.

[4] *See* Tariff Section I.1.3 (describing the mission of the ISO as including: assuring bulk power supply of the New England Control Area confirms to proper standards of reliability; creating and sustaining open, non-discriminatory, competitive, unbundled markets for energy, capacity, and ancillary services; allowing informed participation and encouraging ongoing market improvements; providing transparent operation and pricing; providing access to competitive markets; and providing for an equitable allocation of costs, benefits, and responsibilities among market participants).

[5] ISO New England Inc., Pathways Study: Evaluation of Pathways to a Future Grid, (April 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/04/schatzki-et-al-pathways-final.pdf.

[6] ISO New England Inc., 2021 Economic Study: Future Grid Reliability Study Phase 1 (July 29, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/07/2021_economic_study_future_grid_reliability_study_phase_1_report.pdf.

[7] *See* ISO New England Inc., 2050 Transmission Study Preliminary N-1 and N-1-1 Thermal Results, Presentation to the NEPOOL Planning Advisory Committee (March 16, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/03/a4_2050_transmission_study_preliminary_n_1_and_n_1_1_thermal_results_presentation.pdf.; *see also* ISO New England Inc., 2050 Transmission Study Updated Results and Approximate Duration of Overloads, Presentation to the Planning Advisory Committee (July 20, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/07/a7_2050_transmission_study_updated_results_and_approximate_frequency_of_overloads_1.pdf.

[8] *See* ISO New England Inc., Operational Impact of Extreme Weather Events: Energy Security Study Performed in Collaboration with EPRI, Presentation to the NEPOOL Reliability Committee (July 19, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/07/a06_operational_impact_of_extreme_weather_events.pptx.

region well-situated to manage New England's evolving resource mix, electrification of the region's heating and transportation sectors, and the resulting expected long-term growth in future energy demand.

Clean Energy Transition and the Evolving Resource Mix. As part of the ISO's responsibility to administer the New England wholesale electric markets in a non-discriminatory manner and to ensure reliability standards are maintained, the ISO must plan for a system that accommodates the legislatively-enacted carbon emission reduction goals of the New England states. To better understand the implications of the region's ambitious clean energy goals over the next twenty years, the ISO has undertaken a series of economic studies including the recent Pathways Study and Future Grid Reliability Study.

Released in April 2022, the Pathways Study examines the energy system implications of select policy and regulatory approaches, or "pathways," to achieving the New England states' clean energy goals. These were modeled as a region-wide carbon emissions target of 80 percent below 1990 levels by 2040 (the "decarbonization scenario").[9] The region recognizes that there are many possible policy and regulatory paths that may be undertaken to achieve these ambitious long-term goals. Accordingly, the Pathways Study examined four different policy and regulatory pathways to evaluate their ability to cost-effectively achieve the decarbonization scenario.[10] In

[9] *See* ISO New England Inc., Pathways Study: Evaluation of Pathways to a Future Grid, at 5 (April 2022) (referring to a common set of data and assumptions relating to decarbonization as the "Central Case"), *available at* https://www.iso-ne.com/static-assets/documents/2022/04/schatzki-et-al-pathways-final.pdf.

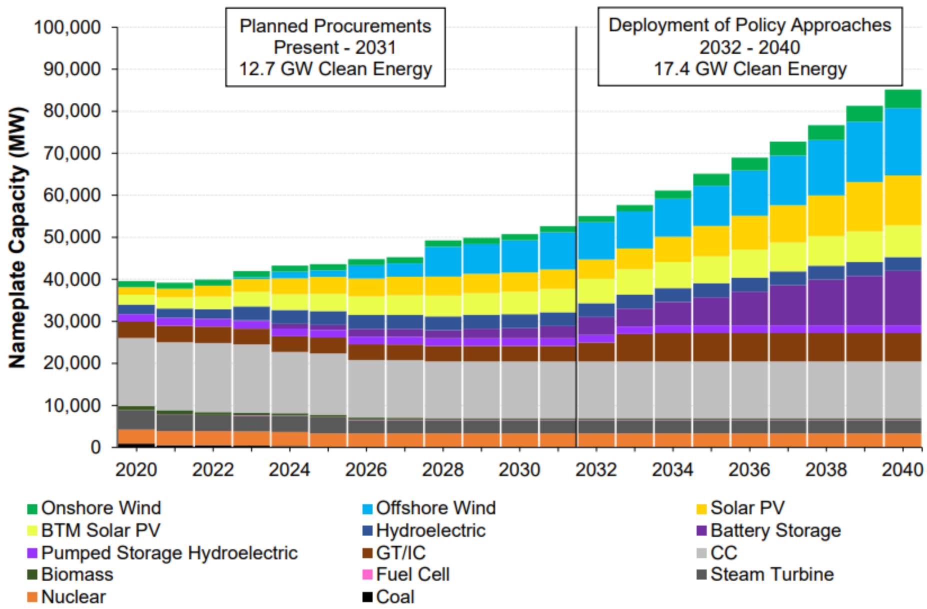
[10] The following pathways were studied: (1) the Status Quo, which assumes continued bilaterally-based, state-directed contracting for clean energy resources by state-regulated distribution utilities; (2) creation of a Forward Clean Energy Market ("FCEM"), a concept that entails a centralized, auction-based, forward market for a new type of "clean-energy certificates" awarded to resources that generate such clean energy, with the costs of the FCEM allocated to participating states' electric ratepayers; (3) Net Carbon Pricing, which establishes a price-per-unit of carbon emissions to be paid by any emitting electric generator in combination with a rebate mechanism that returns (or "nets") the total emissions-related fees paid by emitting generators to electric ratepayers; and (4) a "hybrid" approach that combines a (lower) net carbon price on emitting generation sources with a FCEM in which only newly-developed renewable-energy resources are eligible to participate.

evaluating these policy pathways, the study developed common assumptions about future electric loads, resource costs and available technologies, and environmental emission target trajectories from present to 2040. These common assumptions were then supplemented with further policy and implementation assumptions specific to each of the four pathways. For example, to model the resource mix and capacity additions that may be necessary through 2040 under the Status Quo pathway,[11] the study assumed a certain number of clean-energy resources would be developed in response to specific existing renewable energy procurement mandates, and then modeled the most cost-effective resource mix to simultaneously meet both (i) forecast regional electricity demand through 2040, and (ii) the New England States' legislatively-enacted emission reduction goals by 2040. Assuming the region continues with its existing Status Quo regulatory policy approach to clean energy, this portion of the study developed the region's expected least-cost resource mix that would achieve the decarbonization scenario's 80 percent carbon emissions goal by 2040.

Figure 2 demonstrates the study's findings regarding New England's changing resource mix by technology, for the Status Quo pathway. As noted above, this pathway achieves the states' emissions reduction goals by 2040, but assumes that the region does not adopt a new net carbon pricing mechanism, a FCEM, or some combination thereof, and instead continues with bilateral procurements of clean energy by the states to achieve their clean energy goals.

[11] The Pathways Study used two simulation models to develop common assumptions for its central case, a Capacity Expansion Model and an Energy Market Simulation Model. The Capacity Expansion Model simulated the timing of new resource entry and resource exit decisions. The Energy Market Simulation Model simulated the energy and ancillary service markets across each of the 8,760 hours in a given year.

Figure 2. Resource Mix, Status Quo Policy Approach, 2020-2040 (MW)



As Figure 2 indicates, clean energy resources, including solar photovoltaic (behind-the-meter and utility scale) and wind (offshore and onshore), are expected to experience significant growth in the coming years. In total, they reach more than 48 GW in nameplate capacity, and approximately 65 percent of the system's total nameplate capacity, by 2040.[12] These investments in clean energy resources are accompanied by growth in battery-energy storage resources, as evident in Figure 2, particularly in the 2032-2040 timeframe. By 2040, the study indicates approximately 13 GW of battery storage by nameplate capacity.[13] Taken together, the growth in renewable-energy resources and energy-storage technologies is driven by the states' decarbonization targets, and highlights the importance of the first pillar of a modernized electric system: clean energy. The Pathways Study also projected significant growth in regional

[12] ISO New England Inc., Pathways Study: Evaluation of Pathways to a Future Grid, at 44 (April 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/04/schatzki-et-al-pathways-final.pdf.

[13] *Id*.

electricity demand over time. While the resource mix in Figure 2 is expressed in terms of nameplate capacity, Figure 3 summarizes the energy production (in MWh) by technology type for the same Status Quo pathway.

Figure 3. Generation Mix, Status Quo Policy Approach, 2020-2040 (MWh)

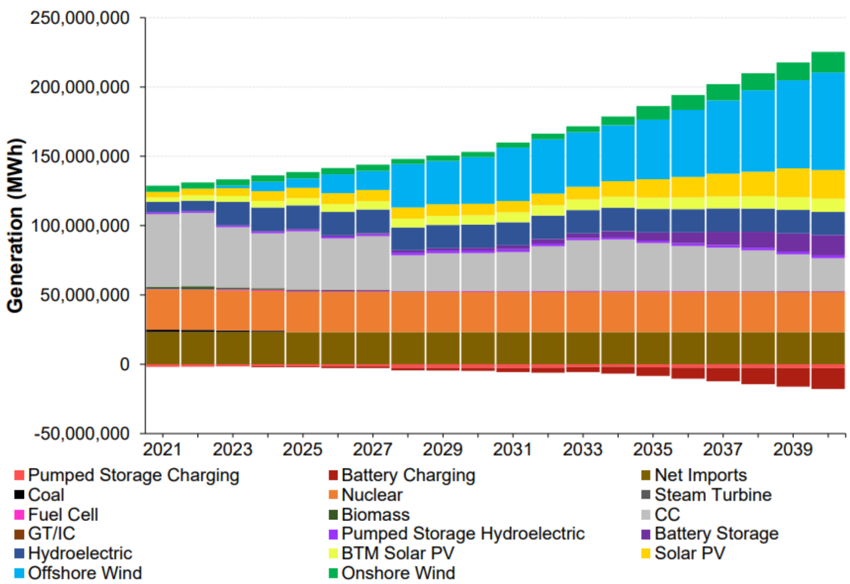


Figure 3 highlights the dramatic projected growth in energy production from wind-energy resources (primarily offshore wind) and, to a lesser extent, solar photovoltaic resources. This substantial growth in clean energy resources' production is the primary mechanism by which the region achieves the states' 2040 carbon emissions targets for the electricity sector. Notably, Figure 3 also indicates that gas-fired resources' electricity production is projected to decline materially (albeit with some annual variation) over the total study horizon, as their output is displaced by renewable-energy resources' production.

Balancing Resources and the Evolving Resource Mix. The findings in the Pathways Study are also revealing with respect to the second pillar of the clean energy transition: the need for flexible balancing resources that can reliably deliver energy to meet electricity demand when weather-dependent renewable-energy resources do not.

More specifically, Figure 2 above shows that fossil-fired generation resources are expected to remain a substantial portion of a least-cost system resource mix through the study horizon. The study identifies the continued service of approximately 20 GW of gas-fired resources as far out as 2040; this is approximately 2 GW *more* than New England's current fossil-fired generation fleet. Importantly, the continued operation of these (primarily combined-cycle and simple-cycle) gas combustion turbines still results in a system that achieves the New England States' emission reduction targets for 2040.

The reason that, under the Pathways Study, these fossil-fired balancing resources continue to be part of the least-cost resource mix in a highly-decarbonized New England electric system is simple: to meet future electric load, the Pathways Study's detailed hourly modeling indicates there are periods when renewable energy output is low, and other balancing resources (such as batteries and gas-fired resources) are needed to support the region's electric load for extended periods.

The ISO and regional stakeholders have also examined these balancing energy issues in other studies, focusing on flexibility and related system reliability requirements. A second major study, the Future Grid Reliability Study, used the ISO's production-cost modeling and related tools to analyze the need for ancillary services, including reserves and regulation, in order to balance the variation in energy output from renewable-energy resources. Under a deep decarbonization scenario, the analysis showed a significant increase in the quantities needed for operating reserves and regulation. The amounts tracked the penetration of weather-dependent renewable-energy resources, and the variability of underlying forecast inputs (*e.g.*, variability in forecast renewable output and net loads).[14] The significantly greater need for regulation and operating reserves was tempered in versions of the deep decarbonization scenario that maintained (all) existing dispatchable resources, or that modeled the entry of new dispatchable resources.[15]

Another component of the Future Grid Reliability Study, a probabilistic "resource availability" analysis, showed that the entry of dispatchable generation resources to balance renewable energy output would significantly reduce the renewable resource buildout necessary to meet the New England States' emission goals. For example, the modeling indicated that 3,000 MW of new fully dispatchable units could displace more than 17,000 MW of renewables with more limited dispatch capability that would otherwise be necessary to achieve emission reduction targets.[16] This analysis serves to further highlight the importance of balancing resources in delivering a clean, reliable, cost-effective energy system.

Taken together, these detailed studies underscore two key points. One is the importance of the ISO's second pillar of a modernized electric system: ensuring there are sufficient flexible resources to balance variation in renewable-energy resources' production. Based on the data presently available, the Pathways Study indicates this is most cost-effectively achieved when the system continues to maintain a fleet of fossil-fired (primarily combined-cycle) resources with a

[14] *ISO New England Inc.*, 2021 Economic Study: Future Grid Reliability Study Phase 1 Reliability Scenario Results, Slide 29 (April 28, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/04/a14_2021_economic_study_fgrs_phase_1_reliability_scenario_results.pdf.

[15] *Id*.

[16] The 3,000 MW of new fully dispatchable units that, for the purposes of scenario development, were assumed to be emission free. Examples include today's fossil-fuel units running on synthetic or renewable fuel, new small modular nuclear units, co-located storage and renewables, large-scale solar or renewables operated in particular ways to maximize dispatchability, or imported hydro-power from Québec.

total installed capability comparable to, or greater than, their total capacity today;[17] however, their annual energy output declines materially over time as their production is displaced by renewable-energy resources.

The second point is that as growth of renewable-energy resources continues in the region, the reliability of the bulk power system will increasingly depend on market mechanisms designed to attract and retain balancing resources that can meet growing energy, reserves, and regulation needs. These capabilities should be viewed as a long-term complement to (and not a substitute for) the inherently variable nature of renewable-energy resources' output.

Energy Adequacy and the Evolving Resource Mix. The continued importance of the system's gas-fired resources, even as far out as 2040, highlights another challenge and the third pillar of New England's clean energy transition: The need for a long-term solution that assures sufficient input energy is available to the resource fleet during adverse weather, when the region's renewable-energy resources may have low output and, during cold-weather conditions, when the region's natural gas-pipeline system is severely constrained.

Thanks in part to market design and operational enhancements developed in the wake of the 2013-14 Polar Vortex, and in part to relatively moderate winter weather in the years since, New England's bulk electric system has avoided disruption in spite of persistent threats to energy adequacy. But the region continues to experience difficulty siting new energy infrastructure that could address energy adequacy concerns; this is true for new fossil-fired generation resources and fuel delivery infrastructure, for new large-scale renewable energy projects, and for new transmission resources that would better connect New England to adjacent regions. As the ISO's

[17] In the FGRS scenario discussed above, these fossil-fired dispatchable units were retained, but also supplemented by 3,000 MW of emission-free dispatchable resources.

2018 Operational Fuel Security Analysis indicated,[18] an extended outage at one of several key facilities — a natural gas pipeline compressor station, the Everett Marine Liquefied Natural Gas ("LNG") import facility in Massachusetts and the Mystic 8 and 9 generators it fuels, the Saint John LNG import facility in Canada,[19] or the Millstone nuclear power plant — would threaten the region's ability to reliably operate the electric system, particularly during cold winter conditions.

In addition, these concerns are exacerbated by ongoing geopolitical conflict in Eastern Europe, and the consequent impact on the price and availability of fossil fuels – and LNG in particular, which is a critical factor in preserving winter reliability. The ISO is actively engaged with the EPRI to better model potential energy adequacy impacts during adverse weather events, particularly when seasonally-constrained interstate gas pipelines serving New England may be incapable of satisfying the full generation needs in New England.

Supplementing the ISO's ongoing efforts to better understand the energy adequacy implications of the changing resource mix, the Future Grid Reliability Study also provided a limited set of analyses on regional input (fuel) energy demand. The study's production cost results revealed that significant penetrations of renewables, along with increased electrification, will continue to result in significant natural gas demand during cold-weather periods when wind and solar are experiencing production lulls.[20] Figure 4 illustrates this finding, and indicates the

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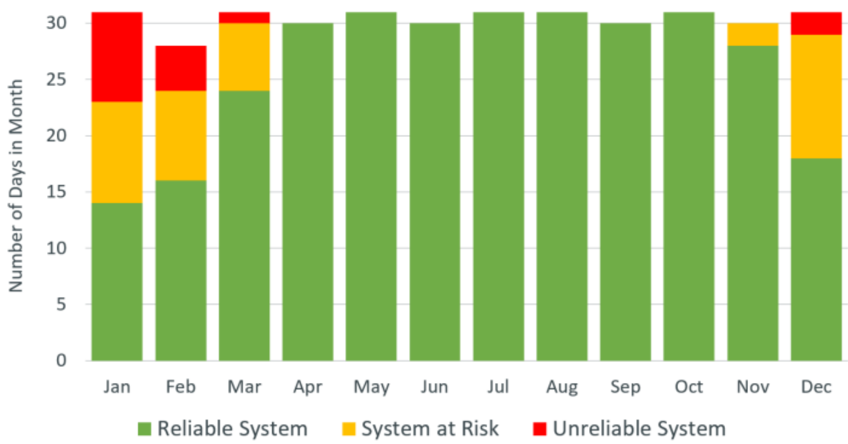
[18] ISO New England Inc., 2018 Operational Fuel-Security Analysis, at 50 (January 17, 2018), available at https://www.iso-ne.com/static-assets/documents/2018/01/20180117_operational_fuel-security_analysis.pdf.

[19] The Saint John LNG facility was formerly known, and described in the 2018 Operational Fuel Security Analysis as, Canaport.

[20] The study's cold weather modeling used a single historical weather year, based on the weather in 2019, to model the need for gas and electricity during 2040. The 2019 weather year was less severe than the most demanding winters in recent history, and the modeled natural gas supply risks should therefore be viewed within the context of that assumption. *See* ISO New England Inc., 2021 Economic Study: Future Grid Reliability Study Phase 1, at 51 (July 29, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/07/2021_economic_study_future_grid_reliability_study_phase_1_report.pdf.

number of days per month that natural gas supply constraints would place system reliability at risk in 2040. Assuming natural gas availability at levels consistent with the deep decarbonization scenario envisioned by the study, winter days with low renewable-energy resource output may result in the potential for a daily natural gas shortfall of nearly 1 Bcf.[21]

Figure 4. Days per Month of Natural Gas Supply Risk Under Deep Decarbonization



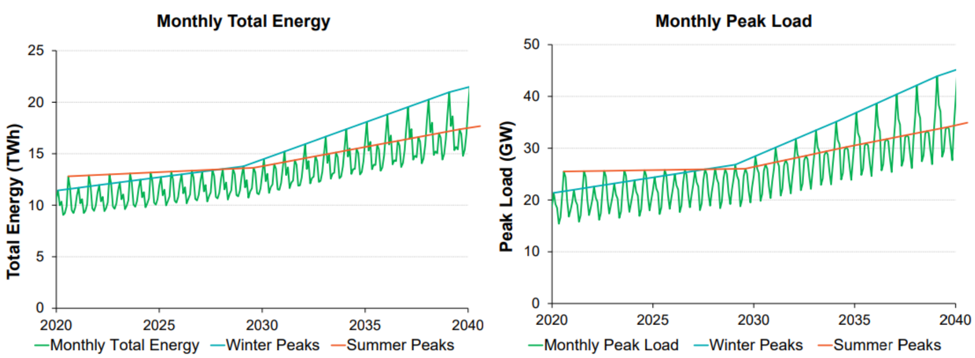
These forecasted shortfalls and related system risk days highlight the continued importance of energy adequacy, and the need for a robust supply chain of energy inputs, even as gas-fired resources become a smaller portion of the overall energy production annually in the New England system.

[21] This figure is based on electric load and resource mix projections for 2040, but also considers the availability of pipeline gas, liquefied natural gas, and storage facilities. The study projected future gas availability based on current and future pipeline infrastructure, publicly available local distribution company forecasts, and a comparison of heating degree days and demand that includes pipeline natural gas and injections of liquefied natural gas. The year 2025 was chosen to approximate demand during 2040, representing the likelihood of continued near-term gas demand growth, followed by regional gas demand reduction based on electrification projections. *See* ISO New England Inc., 2021 Economic Study: Future Grid Reliability Study Phase 1, at 46 (July 29, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/07/2021_economic_study_future_grid_reliability_study_phase_1_report.pdf.

Transmission Investments and the Evolving Resource Mix. Coincident with the above-described clean energy goals is a projected growth in peak electricity demand on the New England portion of the bulk electric system. This is largely the result of the states' planned efforts to electrify the region's building heating systems, projected growth in electric vehicles and, more generally, the electrification of transportation systems.

Heating electrification efforts alone are projected to approximately double the region's winter peak load over the next two decades. As demonstrated in Figure 5, this demand growth is projected to potentially shift New England's bulk electric system load from a summer peaking system today to a winter peaking system within the next ten years.[22]

Figure 5. Modeled Monthly Energy and Monthly Peak Load, 2020-2040 (TWh and GW)

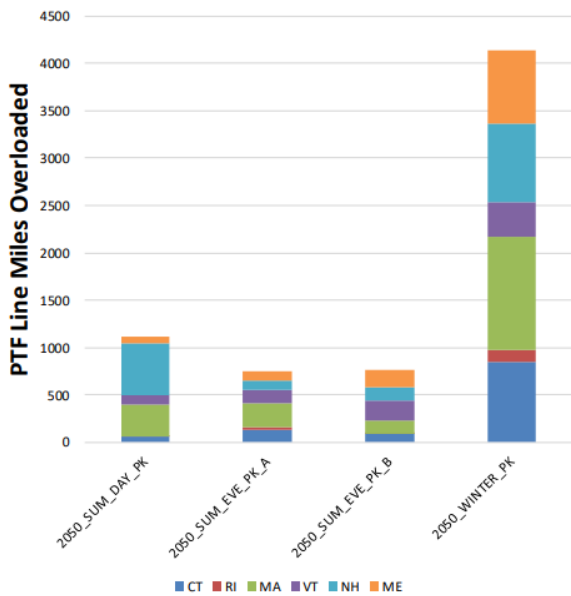


In order to maintain reliability in the face of this expected peak load growth, and to integrate the additional renewable-energy resources to achieve the region's emission reduction

[22] The above-cited load growth assumptions in the Pathways Study's decarbonization scenario are consistent with legislatively enacted emission reduction mandates, and based on the load estimates developed initially in the Massachusetts 80x50 decarbonization study. ISO New England Inc.'s 2022 Capacity, Energy, Load, and Transmission Study assumes decarbonization strategies that more closely resemble existing policies and programs, and therefore does not project that the system becomes winter peaking within the next ten years. This juxtaposition serves to highlight the inherent uncertainty associated with projecting system conditions for a ten-year future time horizon.

goals, large regional investments in transmission may be necessary. Building on the analysis completed as part of the Pathways Study and Future Grid Reliability Study, the ISO is in the midst of developing the 2050 Transmission Study.[23] Although this work remains ongoing, preliminary results indicate that substantial investments in transmission will be necessary to satisfy both summer and winter peaking needs, but with winter representing the majority of investment needs.

Figure 6. Total PTF Line Miles Overloaded for the 2050 Cases



[23] Subsequent iterations of this analysis, while still preliminary, have resulted in fewer thermal violations but still projects a similar magnitude of system investments will be necessary, and maintains the emphasis on winter peak. *See* ISO New England Inc., 2050 Transmission Study Preliminary N-1 and N-1-1 Thermal Results, Presentation to the NEPOOL Planning Advisory Committee (March 16, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/03/a4_2050_transmission_study_preliminary_n_1_and_n_1_1_thermal_results_presentation.pdf.; *see also* ISO New England Inc., 2050 Transmission Study Updated Results and Approximate Duration of Overloads, Presentation to the Planning Advisory Committee (July 20, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/07/a7_2050_transmission_study_updated_results_and_approximate_frequency_of_overloads_1.pdf.

As an illustration of the needs for greater transmission investment and infrastructure to support the clean energy transition in New England, Figure 6 highlights the miles of thermal overloads on Pooled Transmission Facilities forecasted to occur by 2050 during summer and winter evening peaks.[24] It shows that without substantial transmission development, the system will experience a dramatic increase in projected transmission element overloads under the modeled levels of new renewable-energy resources envisioned by 2050 in that study. This analysis highlights the continued importance of transmission investments as the New England grid evolves to satisfy states' emissions reductions targets. In fact, the New England states are already taking steps to solicit investments in transmission intended to facilitate the near-to-medium-term deployment of offshore wind, having issued a Request for Information relating to a modular offshore wind integration framework in September 2022.[25]

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In summary, New England's energy systems are in the early stages of a significant shift. To avoid potentially disruptive effects of this shift, the ISO is actively engaging in numerous pro-active studies, discussions with stakeholders and states, and long-term planning efforts that recognize the need to focus on clean energy, balancing resources, energy adequacy, and transmission investments. As evidenced by the ISO's efforts to date, including the results of the Pathways Study, the Future Grid Reliability Study, the ongoing 2050 Transmission Study, and ongoing work with EPRI to understand implication of extended duration adverse weather events,

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[24] Preliminary analysis has indicated that resource curtailments could alleviate a portion of the projected 2050 overloads, but the study's full findings remain pending.

[25] Regional Transmission Initiative Notice of Request for Information and Scoping Meeting (September 1, 2022), *available at* https://newenglandenergyvision.files.wordpress.com/2022/09/transmission-rfi-notice-of-proceeding-and-scoping.pdf

the ISO is committed to robust stakeholder processes and proactive planning to ensure the continued reliable and cost-effective operation of New England's Bulk Electric System.

II. ENERGY SYSTEM CAPABILITIES AND THE CHANGING RESOURCE MIX

1. *What system needs (type and magnitude) has the RTO/ISO experienced that are attributable to changes in the resource mix and customer load profiles? How do these system needs, including types and magnitudes of net load variability and uncertainty, vary over different time horizons in the E&AS markets? For example, does a particular need exist within a real-time market interval, within an operating day, between day-ahead and real-time markets, across multiple days, and between seasons? RTO/ISO materials, such as previously published RTO/ISO whitepapers or previous filings with the Commission, may be incorporated by reference as needed. What specific resource capabilities could address these needs (e.g., dispatchable generation)?*

As discussed above, New England's energy system is in the midst of extensive change. After a two-decade long shift to a generating fleet now composed primarily of natural gas-fired resources and little annual load growth, the New England States' emission reduction targets may soon result in an increasingly electrified energy sector and the coincident need for development of new clean generating resources. The past shift to a natural gas-fired generation fleet and recent growth in renewable-energy resources has increased the region's reliance on energy inputs that are increasingly weather-dependent. These weather-dependent energy inputs – whether sun, wind, or constrained natural gas supplies for power generation – has increased net load variability, challenged forecasting on both short and long-term timeframes,[26] and contributed to concerns over resource dependability and energy adequacy during sustained periods of adverse winter weather. The impact of these factors will likely increase over the next five and ten years, as the system is augmented with substantial amounts of offshore wind, solar photovoltaic (both

[26] ISO New England's forecasting is generally quite accurate, targeting daily peak load forecasting errors of 2.6% or less during the summer months (based on day-ahead forecasts) and 1.8% or less during non-summer months. *See* NEPOOL Participants Committee, ISO-NE Chief Operating Officer Report, at 21 (January 6, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/01/january-2022-coo-report.pdf.

behind and in front of the meter), and other generating resources currently in various stages of development or procurement.[27]

In this environment, we interpret the current and future "system needs" in broader terms than the narrow reading of that phrase proffered in the Order Directing Reports.[28] Generally, we view the system's future needs as comprising three conceptually distinct categories: (A) the **physical capabilities** of the system's resource mix to deliver energy, at the right times and in the right quantities; (B) the **informational capabilities** of the ISO, which are necessary to coordinate that energy delivery efficiently and reliably; and (C) the **markets' capabilities** to signal, incent, and coordinate investment by private investors in resources' capabilities (over the long-term), and to ensure resources' performance is appropriately compensated and therefore adequately provided (over the short-term). Category (A) in this taxonomy aligns most closely with the characterization of "system needs" provided in Section II of the Order Directing Reports; addressing Categories (B) and (C) provides a more fulsome answer that highlights several aspects of the ISO's planned approach to addressing the anticipated challenges. We therefore address each category in our response below, in turn.

Physical Capabilities of the System's Resource Mix. Identifying resource physical capabilities that should be developed or preserved will be an important strategy for ensuring a reliable system, in light of the above-described factors. As the Commission has recognized, the evolving resource mix and customer load profiles may result in the need for a system and

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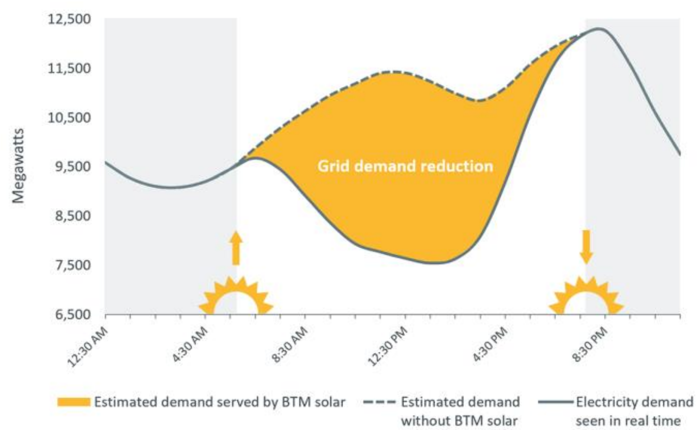
[27] Wind, battery storage, and solar represent 51%, 26.2% and 18.7%, respectively, of the region's forecasted nameplate capacity additions during the next five years. *See* NEPOOL Participants Committee, ISO-NE Chief Operating Officer Report, at 46 (June 21, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/06/june-2022-coo-report.pdf.

[28] Order Directing Reports at PP 3–4. ("Changing *system needs* include the need for greater operational flexibility … fast ramp-up and ramp-down rates, short start-up and shut-down times, and long-duration delivery of energy") (emphasis added).

participating resources that must increasingly accommodate longer and steeper net load ramps, be capable of withstanding operational uncertainties, and sustain energy production dependably during extended durations of adverse weather.[29]

Net Load Ramping. The potential for sustained, multi-hour, steep increases in net load during certain portions of each operating day, and corresponding sustained steep decreases in net load during other portions of the day, will continue to grow coincident with an increasingly weather-dependent generation mix.[30] Although the effect of net load ramps associated with weather-dependent generation is not yet as significant in New England as it is in other regions, it nonetheless affects daily load profiles. For example, Figure 7 illustrates the impact of behind-the-meter solar photovoltaics on the system load shape on a Sunday during May 2022.[31]

Figure 7. Load Shape Impacts of Behind the Meter Solar, May 2022



[29] Order Directing Reports at P 3.

[30] The Commission Staff Whitepaper defined net load as "load minus the output of non-dispatchable resources," citing "expected and reasonably forecastable changes within the operating day and across seasons" as one of two primary drivers of net load variability. Commission Staff Whitepaper, *Energy and Ancillary Services Market Reforms to Address Changing System Needs*, at 7-8, Docket No. AD21-10-000 (September 7, 2021) (internal quotations and citations omitted).

[31] ISO New England Inc., 2021 Economic Study: Future Grid Reliability Study Phase 1, at 13 (July 29, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/07/2021_economic_study_future_grid_reliability_study_phase_1_report.pdf.

At 12 pm, behind-the-meter solar photovoltaics reduced grid demand by more than 3,000 MW, though this reduction did not impact the peak load, which occurred after the sun had set. The shaded area represents the net load variability attributable to behind-the-meter solar photovoltaic output during that day. The graph also indicates the significant ramping needs of nearly 4,000 MW that occurred between 3 p.m. and 8 p.m. on that day.

The ISO currently addresses reasonably foreseeable multi-hour net load ramps through its unit commitment and dispatch process. That process begins with a Day-Ahead Energy Market that solves for efficient unit commitment, dispatch, and prices on an hourly basis, based on bid-in demand from energy buyers and supply offers from sellers.[32] After supply and demand clear the Day-Ahead Energy Market, the ISO then conducts a Resource Adequacy Assessment, based on the ISO's forecast energy and reserve requirement, to determine whether to commit any additional resources to meet demand and reserve requirements at each hour of the following day.[33] The results of this Resource Adequacy Assessment form the basis for the next day's Operating Plan. If foreseeable net load ramps differ *during* the Operating Day from those anticipated in the Day-Ahead Energy Market and Resource Adequacy Assessment process, the ISO may re-dispatch committed resources, extend or shorten the commitment period for day-ahead scheduled resources, or issue new commitments to ensure the system's ability to meet sustained, multi-hour steep load ramps (in either direction) and the concurrent availability of adequate operating reserves.[34] Based on limited observed issues related to an inability to meet

[32] Tariff Section III.1.10.1(d) ("Scheduling encompasses the Day-Ahead and hourly scheduling process, through which the ISO determines the Day-Ahead Energy Market schedule and determines, based on changing forecasts of conditions and actions by Market Participants and system constraints, a plan to serve the hourly energy and reserve requirements of the New England Control Area.").

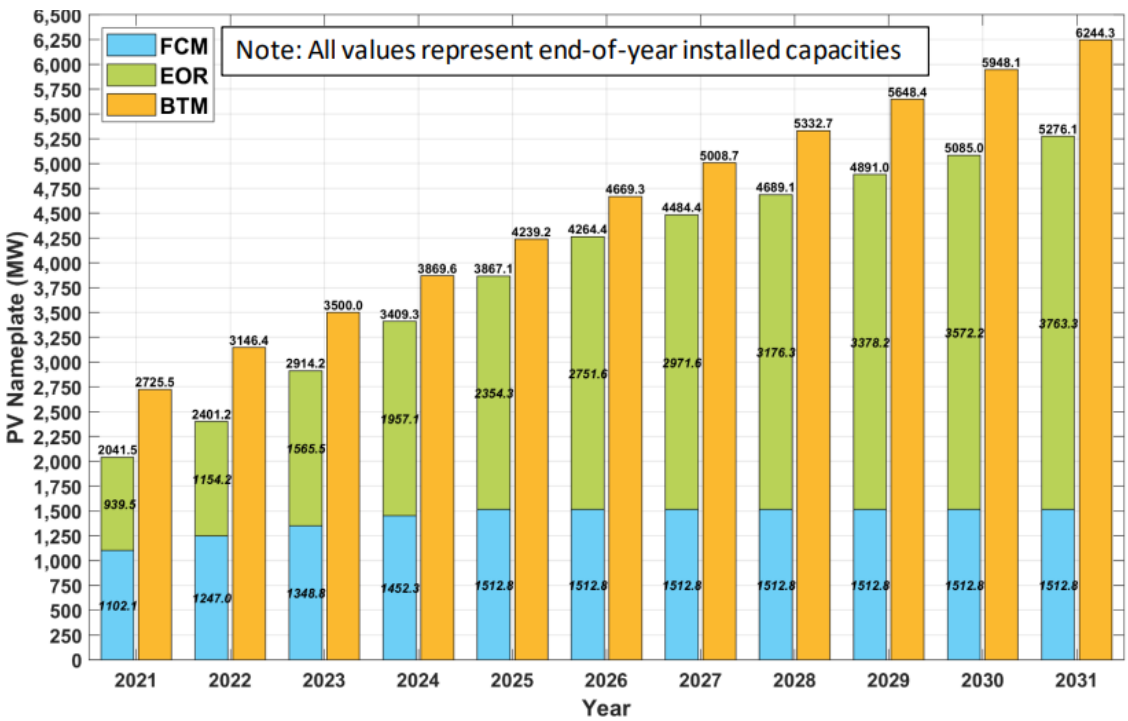
[33] The ISO also performs a Security Constrained Reserve Adequacy Analysis that informs the next-day Operating Plan.

[34] For a summary of the requirements that inform the ISO's next day Operating Plan, *see* ISO New England Inc., Reliability Standards Supporting Day-Ahead Ancillary Services Requirements, July 3, 2019 Memo to NEPOOL

foreseeable hourly net ramps, the ISO has not historically procured ramping capabilities associated with foreseeable hourly net load ramps through use of a market product for that specific purpose.

However, the ISO is cognizant that the need for resource ramping capabilities at the system level will continue to grow over time as the resource mix and demand behavior (and thus, the net load variability) continues to evolve. As seen in Figure 8, the region's total nameplate photovoltaic capacity was approximately 4,800 MW in 2021, and is expected to rise to approximately 9,000 MW over the next five years, and to 11,500 MW over the next ten, with the majority of that solar photovoltaic capacity being behind-the-meter.[35]

Figure 8. 2022 Photovoltaic Forecast, Cummulative Nameplate Capacity by Category

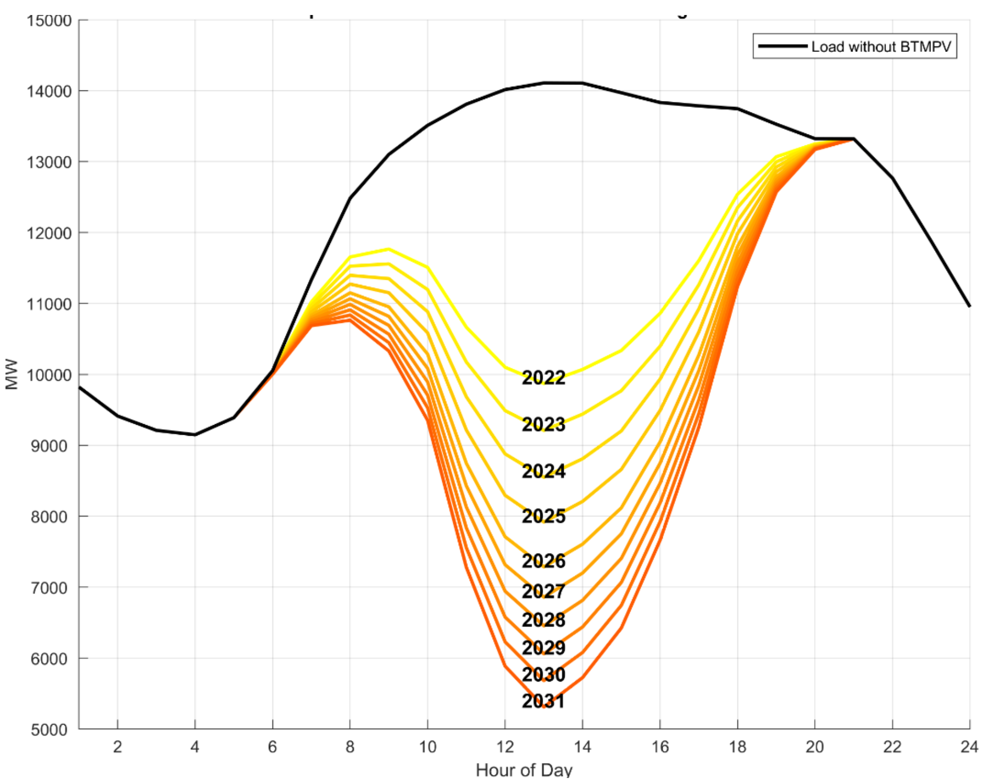


Markets Committee, at 1–5, *available at* https://www.iso-ne.com/static-assets/documents/2019/07/a4b_iso_memo_reliability_standards_supporting_day_ahead_ancillary_services_requirements.pdf.

[35] ISO New England Inc., Final 2022 PV Forecast, at 49 (April 28, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/04/final_2022_pv_forecast.pdf.

Figure 9 applies the projected growth in behind-the-meter solar photovoltaic output to the weather and associated load profile that occurred on May 20, 2022.[36] This projection indicates that ramping needs on a shoulder season day, such as May 20, 2022, may increase significantly over the next decade, based on the proliferation of behind-the-meter solar photovoltaics alone.

Figure 9. Expected ISO-NE Load Profile with Increasing BTM PV



In addition, new wind power resources, most of which will be sited offshore, will also add to the weather-dependent portion of the resource mix in the coming years, with projected

[36] Figure 9 is based on loads and weather as observed during May 20, 2022, and projects out the impact that would be due to forecasted future solar photovoltaic growth in coming years, holding all else constant. For example, it does not include the ISO's projected gross load growth between 2020 and 2031.

nameplate capacity additions of approximately 16,800 MW by 2027.[37] A system capable of accommodating the foreseeable net load ramps resulting from the increase in weather-dependent resources will be important as those resources expand their presence on the system.

While the ISO expects that its existing unit commitment and dispatch process will continue to accommodate forecastable net load ramping, just as it would any other forecastable supply or generation deviations, intertemporal optimization and pricing may present opportunities to more efficiently prepare for and manage the impact of such ramps, as discussed further below in response to Question 5.

Withstanding Operational Uncertainties. The continued growth of weather-dependent generation and customer net loads will require a system and balancing resources that can increasingly accommodate operational uncertainties, *i.e.*, events during the operating day that cannot be easily or accurately forecasted.[38] Historically, the ISO has faced operational uncertainties associated with source-loss (*e.g.*, generator) contingencies, transmission contingencies, forecast accuracy, and among other things, unanticipated changes in weather during the operating day. These operational uncertainties are accommodated through a multitude of market features and operating procedures, including products and procedures relating to regulation and operating reserves.

The New England market for regulation compensates resources for offering the capability to rapidly increase or decrease power output (or power consumption) in response to a signal that

[37] *See* NEPOOL Participants Committee, ISO New England Inc. Chief Operating Officer Report, at 46 (June 21, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/06/june-2022-coo-report.pdf.

[38] In defining net load, the Staff Whitepaper cited "unexpected changes that cannot be forecasted due to the inherent uncertainty of the components of net load (e.g., meteorological conditions)" as one of two primary drivers of net load variability. Commission Staff Whitepaper, *Energy and Ancillary Services Market Reforms to Address Changing System Needs*, at 7–8, Docket No. AD21-10-000 (September 7, 2021) (internal quotations and citations omitted).

varies as often as every four seconds.[39] This capability is important for ensuring the system's frequency remains within acceptable limits during very limited duration disturbances, such as the unexpected and transitory loss of a line, an extremely abrupt change in a generator's output, or a rapid increase in consumption at a particular load.[40] It is procured competitively in the real-time markets as a symmetric product, requiring that participating resources be capable of increasing or decreasing their consumption within the regulating range offered by the resource.

As growth of weather-dependent generation and customer loads continues, it is likely that the need for regulation will experience commensurate growth, and that the nature of the product procured may evolve along with that growth. For example, a passing thunderstorm during a summer afternoon may lead to abrupt changes in cloud cover that causes a rapid and localized decrease (also potentially followed by an increase as the storm passes) in output of solar photovoltaic resources. Under limited penetrations, the reliability impacts of such an event would generally be diluted by the output of unaffected resources, but in a future where Intermittent Power Resources represent a much larger portion of the resource mix, localized reliability impacts may require a more extensive procurement of regulation than the markets currently acquire.

The New England market for operating reserves compensates resources for their ability to provide energy by increasing their energy output or decreasing their consumption within ten or thirty minutes of ISO's request.[41] Operating reserves are procured through both real-time and forward markets for Ten-Minute Spinning Reserves, Ten Minute Non-Spinning Reserves, and

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[39] Tariff Section III.14.2(b)(v) (requiring that a facility capable of providing regulation must be capable of receiving and following an Automatic Generation Control (AGC) Setpoint sent electronically at four second intervals).

[40] Currently, the majority of regulation is provided by either conventional generating resources or battery storage.

[41] Tariff Section III.9 (Forward Reserve Market); Section III.10 (Settlement for Real Time Reserves).

Thirty-Minute Operating Reserves.[42] The minimum required reserve margin for each of the three types of operating reserve is determined by the system's first and second largest source-loss contingencies, with adjustments for historical reserve non-performance.[43] Operating Reserves are procured and settled on both a system-wide and zonal basis, according to zones determined by the ISO based on a rolling, two-year historical analysis of the daily peak hour operational requirements.[44] Markets for operating reserve are co-optimized with markets for energy, meaning the market clearing model solves for both operating reserves and energy at the same time, providing for the optimal allocation of energy and reserve for each unit. A resource's operating reserves, if activated, must be sustainable for at least one hour from the time of activation.[45] Operating reserves enable the grid to withstand operational uncertainties by serving as a temporary buffer against supply shortfalls or unexpected load increases, allowing the ISO time to commit and dispatch additional resources, as necessary, to balance load with supply.

In the future, the increased potential for operational uncertainties caused by the impacts of weather-dependent resources may drive the need for expansion of operating reserve capabilities beyond the ability to offset transitory localized contingencies, such as the loss of a line or particular generator. A market product may be necessary to address broader operational uncertainties, like when a fleet of weather-dependent resources reduces output unexpectedly for an extended period of time. This will be particularly true between mid-afternoon load troughs,

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[42] *See generally* ISO New England Inc., Manual for Forward Reserve and Real-Time Reserve, Manual M-36, Revision 23 (December 3, 2019), *available at* https://www.iso-ne.com/static-assets/documents/2020/02/manual_36_forward_reserve_and_realtime_reserve_rev23_20191203.pdf; *see also* ISO-NE, Reserve Products and Markets Overview, (April 25-28, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/05/20220425-09-wem101-reserve-products-mkt-overview_PRINT.pdf.

[43] *See* ISO New England Inc., Operating Procedure No. 8 – Operating Reserve and Regulation, *available at* https://www.isone.com/static-assets/documents/rules_proceds/operating/isone/op8/op8_rto_final.pdf.

[44] Tariff Section III.9.2.2.

[45] Tariff Section III.1.7.19.1

when solar irradiance is high, and early-evening peaks when solar irradiance drops off. Offshore wind will likely be subject to similar generation ramps, potentially of an even greater magnitude.

Reliable Operation During Sustained Adverse Weather. The continued growth of resources with weather-dependent energy inputs will require a system and resources that can increasingly deliver sustained energy during long-duration events, including those related to prolonged cold winter conditions, heat waves, and other adverse weather conditions having an impact on the magnitude of customer load and/or the availability of energy from the region's generating resources.

Reliability risks associated with energy adequacy have been a focus of the ISO and New England States for nearly two decades.[46] During that time, the ISO has proposed, altered, or put in place several Tariff-based mechanisms and operational procedures to enhance resource performance capabilities during sustained adverse weather events. Market changes of note have included, but have not been limited to: an increase in the Reserve Constraint Penalty Factor intended to send a stronger price signal during reserve deficiencies;[47] implementation of a pay-for-performance program tying capacity market payments to a resource's performance in the energy and reserve markets during scarcity events;[48] implementation of winter reliability programs to encourage higher levels of stored fuel inventories and to support winter energy

[46] *See* ISO New England Inc., Energy Security Timeline 2004-2025: Multiple Approaches Undertaken to Address Region's Energy Security Risks (December 21, 2021), *available at* https://www.iso-ne.com/static-assets/documents/2021/12/new-england-fuel-risk-2021-2022-necpuc-12-22-2021-final.pdf.

[47] *ISO New England Inc. & NEPOOL Participants Comm.*, Compliance Filing of Two-Settlement Forward Capacity Market Design – Part 1 of 2, Docket No. EL14-52-000, at 4–7 (filed July 14, 2014) (increasing the Reserve Constraint Penalty Factor for 30-Minute Operating Reserves from $500/MWh to $1000/MWh, and the Reserve Constraint Penalty Factor for 10-Minute Non-Spinning Reserves from $850/MWh to $1500/MWh).

[48] *ISO New England Inc. & NEPOOL Participants Comm*, Filing of Market Rule Changes to Implement Pay For Performance in the Forward Capacity Market, Docket No. ER14-1050 (filed January 17, 2014).

adequacy;[49] retention of Mystic Generating Station Units 8 and 9 and the Everett Marine LNG terminal for reliability purposes;[50] implementation of an Inventoried Energy Program providing incremental compensation to resources that maintain inventoried energy for use during cold periods when fuels might become limited;[51] and an Energy Security Initiative proposing to reform ancillary service markets,[52] which was rejected by the Commission without prejudice to any future related proposals.[53]

Over the past several years, to promote continued reliability during sustained duration adverse weather events, the ISO has also implemented operational improvements, including: the development of periodic inventoried fuel surveys; annual winter generator readiness surveys; annual winter generator readiness seminars; regular communications and coordination with gas pipeline operators; and publication of 21 day forward-looking energy forecasts to inform Market

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[49] *ISO New England Inc. & NEPOOL Participants Comm*, Winter 2013-2014 Reliability Program Filing, Docket No. ER13-1851 (filed June 28, 2013)*; ISO New England Inc. & NEPOOL Participants Comm*, 144 FERC ¶ 61,204 (2013) (accepting 2013-14 winter reliability program), *reh'g denied*, *ISO New England Inc.*, 147 FERC ¶ 61,026 (2014); *ISO New England Inc. and New England Power Pool Participants Committee*, 148 FERC ¶ 61,179 (2014) (accepting 2014-15 winter reliability program), *clarification granted*, ISO New England Inc. and New England Power Pool Participants Committee, 150 FERC ¶ 61,029 (2015), *reh'g denied*, *ISO New England Inc. and New England Power Pool Participants Committee*, 151 FERC ¶ 61,052 (2015); *ISO New England Inc. and New England Power Pool Participants Committee*, 152 FERC ¶ 61,190 (2015) (approving 2015-16, 2016-17, and 2017-18 winter reliability programs), *reh'g denied, ISO New England Inc. and New England Power Pool Participants Committee*, 154 FERC ¶ 61,133 (2016).

[50] *ISO New England Inc.*, Compliance Filing to Establish a Fuel Security Reliability Standard, Short-Term Cost-of-Service Mechanism, and Related Cost Allocation for Out-of-Market Compensation, Docket No. EL18-182-000, and Docket No. ER18-2364-000 (filed August 31, 2018);

[51] *ISO New England Inc.*, Inventoried Energy Program Filing, Docket No. ER19-1428-000 (filed March 25, 2019)

[52] *ISO New England Inc.*, Compliance Filing of Energy Security Improvements Addressing New England's Energy Security Problems, Docket Nos. EL18-182-000 and ER20-1567-000 (filed April 15, 2020)

[53] *ISO New England Inc.*, 173 FERC ¶ 61,106 at P 57 (2020) (In rejecting the Energy Security Initiative, the Commission clarified that its action was without prejudice to future day-ahead reserve market proposals that might be submitted independent of the energy security concerns at issue in that proceeding, stating "We further note that nothing in this order prohibits ISO-NE from proposing a day-ahead reserves market independent of any proposal to address the concerns at issue here.")

Participants, regulators, and regional stakeholders of expected energy supply conditions.[54] The ISO also closely monitors generators' daily gas supply nominations, global fuel supply chains, LNG cargoes, and regional fuel oil inventories in order to maintain a high level of situational awareness with regard to regional energy availability.

In the future, when adverse weather events may lead to correlated reductions in the energy output of many resources with "just-in-time" input energy sources (whether renewable-energy resources, pipeline-based natural gas generators, or both concurrently), actions may be necessary to enhance resource performance capabilities during such sustained duration events. To better understand the need for these capabilities, the ISO is currently working with the EPRI to quantify the operational impacts of extreme weather events.[55] The joint effort will include extreme weather modeling based on historical and projected climate data, development of a probabilistic risk model that will account for weather-related limitations on the availability of generating resources, and the adaptation of the ISO's 21 day forward-looking energy forecast to incorporate the results of the models and quantify the risks associated with the identified weather events. This partnership and associated deliverables will supplement the work conducted as part of the 2018 Operational Fuel Security Analysis, and are intended to quantify, as precisely as possible, the depth and duration of the energy adequacy risk facing the region's bulk electric system as the resource mix continues to evolve.[56]

[54] *See* ISO New England Inc., Operating Procedure No. 21 – Energy Inventory Accounting and Actions During an Energy Emergency, *available at* https://www.iso-ne.com/static-assets/documents/rules_proceds/operating/isone/op21/op21_rto_final.pdf.

[55] *See* ISO New England Inc., Operational Impact of Extreme Weather Events: Energy Security Study Performed in Collaboration with EPRI, Presentation to the NEPOOL Reliability Committee (July 19, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/07/a06_operational_impact_of_extreme_weather_events.pptx.

[56] *See Transcript September 13, 2022 Technical Conference Regarding New England Winter Gas-Electric Forum*, Docket No. AD22-9, Tr. 204:15–23 (describing energy adequacy concerns as "a difficult problem, and we are not going to be able to put a fine number on some methodology, but I think the work that has been started with EPRI,

Informational Capabilities. The second category of system needs we have identified are the informational capabilities of the ISO that are necessary to coordinate energy delivery efficiently and reliably. Continued expansion of informational capabilities will be an important element for accommodating the changing resource mix and associated drivers. These informational capabilities relate to ISO near-term demand forecasting, long-term forecasting, electrical disturbance modeling, situational awareness, and resource output coordination.

Near-term Forecasting. From a near-term demand forecasting perspective, each operating day, the ISO currently forecasts hourly system demand three days ahead and daily system peak demand seven days ahead. ISO's demand forecasts are adjusted to account for behind-the-meter photovoltaic output based on an aggregate behind-the-meter solar photovoltaic forecast provided to ISO by a vendor each day looking seven days ahead. As the resource mix and load profiles continue to evolve, however, the ISO may consider the value of informational capabilities that would enable continuing improvements to demand forecasts, including improvements to the vendor-provided behind the meter photovoltaic forecast.

For example, to develop the behind the meter photovoltaic forecast, the ISO currently uses a single vendor, but is working to incorporate additional vendors in the near future. As photovoltaics continue to grow within the resource mix, the ISO believes there is value in the incremental forecasting improvements that might result from engaging with multiple photovoltaic forecast vendors, which would then be blended into a final forecast. This approach

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and I think that there is a lot more analysis that the states in conjunction with the ISO need to do to really begin to define how big this hole is we need to fill and to make sure the solutions we are coming up with are going to make a meaningful contribution.") (Comments of Me. Pub. Utilil. Comm'n. Chairman Philip Bartlett, II); Tr. 267:5–9 ("[t]he kind of open dialogue that we need in the medium term, in the longer term… starts with the ISO in their position of advantage as the grid operator to advance the information to the stakeholder process to help people understand the scope of the problem.") (Comments of Conn. Dept. of Energy and Env't Prot. Commissioner Katie Dykes) would be similar to the approach already taken by the ISO for development of its weather forecast.[57] The ISO is also actively exploring the whether to expand the number of data points used to develop location-specific weather forecasts beyond the current eight cities for which weather is forecasted.

Long-term Forecasting. From a longer-term system planning and modeling perspective, the ISO currently conducts an annual study of capacity, energy, load and transmission needs within a ten year planning horizon ("CELT Report").[58] To develop the CELT Report, the ISO reviews state historical demand data, economic and weather data, and incorporates the impacts of a utility-sponsored energy efficiency program forecast,[59] a behind the meter photovoltaic forecast,[60] a heating electrification forecast,[61] and a transportation electrification forecast.[62] The CELT Report is used as a primary input for the triennial Regional System Plan, the vehicle through which the ISO identifies transmission system investment needs.[63] Once a transmission investment need is identified, the ISO works with the Planning Advisory Committee to develop solutions studies for projects that may satisfy market efficiency or reliability-related needs. As

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[57] *See* ISO New England Inc., Introduction to Wholesale Electricity Markets: Forecast and Scheduling, Reserve Adequacy Analysis, at 23–25 (April 25–28, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/05/20220425-05-wem101-forecast-scheduling-PRINT.pdf.

[58] ISO New England Inc., 2022-2031 Forecast Report of Capacity, Energy, Loads, and Transmission, *available at* https://www.iso-ne.com/static-assets/documents/2022/04/2022_celt_report.xlsx.

[59] ISO New England Inc., Final 2022 Energy Efficiency Forecast (May 2, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/04/eef2022_final_fcst.pdf.

[60] ISO New England Inc., Final 2022 PV Forecast (April 28, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/04/final_2022_pv_forecast.pdf.

[61] ISO New England Inc., Final 2022 Heating Electrification Forecast (April 28, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/04/final_2022_heat_elec_forecast.pdf.

[62] ISO New England Inc., Final 2022 Transportation Electrification Forecast (February 18, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/02/evf2022_forecast.pdf.

[63] Tariff Section II, Attachment K (describing processes for the development of the Regional System Plan and identification of system investment needs); *see also* ISO New England Inc., 2021 Regional System Plan, *available at* https://www.iso-ne.com/static-assets/documents/2021/11/rsp21_final.docx.

load growth begins to return to New England, these long-term planning processes may become more resource intensive than they have been in recent years.

Electrical Disturbance Modeling. Currently, the system studies conducted by the ISO, including Solutions Studies and Interconnection Studies, generally assume prevalence of conventional resources on the system for the purposes of modeling how the grid will react in the event of a fault. However, in a resource mix with a high prevalence of inverter-based resources, the system would react differently to localized electrical short-circuits and electrical faults than it would if conventional generation were the prevalent source of electric power injection. When an electrical fault occurs on the transmission system, conventional resources respond and provide approximately five times their rated current, making it easier to maintain system voltage at acceptable levels during the fault. Unlike conventional resources, inverter-based resources are only capable of producing their rated current, and in many cases the capability of inverter-based resources deployed prior to 2019 to ride-through temporary and limited voltage fluctuations is not assured.[64] This inability of inverter-based resources to exceed their rated current applies not only to distributed battery, photovoltaic, and wind sources, but also to large, centralized, High Voltage Direct Current ("HVDC") projects that in many circumstances may be necessary to accommodate offshore wind or distant hydropower resources.

As the resource mix evolves, the ISO will need to reconsider the assumption that conventional resources will be the prevalent resource when modeling solutions to electrical disturbances and identified transmission system needs. The ISO will need to invest in capabilities that would enable electromagnetic-transient modeling of inverter-based resources, as

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[64] *See* ISO New England Inc., Transmission Planning for the Clean Energy Transition, at 11–16 (May 18, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/05/a7_transmission_planning_for_the_clean_energy_transition_updates_on_der_modeling_assumptoions.pdf.

well as potential requirements for submission of electromagnetic-transient modeling information from resources prior to interconnection.[65] Additional infrastructure investments in Phasor Measurement Units will also be needed to analyze transient system events that require higher granularity data than currently installed technologies are able to provide, and enable proper validation of electromagnetic-transient models.[66] Such modeling and validation would permit the ISO to better understand the likely performance of a resource and the grid during contingencies, localized faults, and other unanticipated voltage variation events.

*Situational Awareness***.** Situational awareness describes the ISO's ability to monitor and understand what is occurring on the bulk electric system at each instant in time. The ISO's primary tool for maintaining situational awareness is its detailed, electric system network model. The network model is an extensive database describing many aspects of the transmission system and its interconnected resources. This information supports the software systems and visual displays critical to the economic dispatch and reliable operation of the grid. A generator that is represented in the network model is "visible" to the ISO in the Control Room, in the sense that telemetry describing the generator's current status is available to system operators on numerous

[65] *See* NERC, Technical Report on Bulk Power System-Connected Inverter-Based Resource Modeling and Studies, at 13–15 (May 2020), *available at* https://www.nerc.com/comm/PC/InverterBased%20Resource%20Performance%20Task%20Force%20IRPT/IRPTF_IBR_Modeling_and_Studies_Report.pdf.

[66] *See* ISO New England Inc., Operating Procedure No. 22 – Disturbance Monitoring Requirements (OP-22), *available at* https://www.iso-ne.com/static-assets/documents/rules_proceds/operating/isone/op22/op22_rto_final.pdf ; *see also* PJM Press Release, *Synchrophasor Technology Improves Grid Visibility* (July 12, 2022) (stating "[p]hasor measurement units (PMUs) are monitoring devices that collect synchrophasor data and can reveal subtle differences and changes in these characteristics across the bulk electric system. These changes may be undetectable through the traditional supervisory control and data acquisition (SCADA) technology that PJM uses to monitor and control the grid," which generally "take measurements every two to 10 seconds, [compared to] synchrophaser devices [that] typically record measurements 30 times per second"), *available at* https://www.pjm.com/-/media/about-pjm/newsroom/fact-sheets/synchrophasor-technology.ashx.

display screens, and is accounted for in the software systems used to dispatch resources and monitor transmission system conditions in a reliable and economic manner.

As the resource mix and customer load profiles continue to evolve, enhanced visibility into behind-the-meter resources will be increasingly important. Although the ISO's network model provides extensive insight into the constantly variable balance of loads and supply on the New England Bulk Electric system, the majority of photovoltaic resources are located behind a customer's meter,[67] and are essentially "invisible" to the ISO's operations and network model, except for their input on net load. Only after the sun has set is a vendor able to provide ISO forecasters with actual behind-the-meter energy output values for the day. Same-day behind-the-meter solar photovoltaic forecasts are available to the ISO periodically: twice in the morning before the final demand forecast is published, and once in the afternoon. However, the infrequency of these forecasts limits the ISO's ability to effectively incorporate any updates into the regional demand forecast for the remainder of the day. When the ISO observes that actual solar production is differing markedly from forecasted production during a given day, it re-adjusts the day's operating plan to balance the system.

As the resource mix continues to evolve, the ISO may consider whether the benefits of a more nuanced accounting of behind-the-meter solar photovoltaics in its forecast and markets would outweigh any related costs. For example, if the ISO were able to receive updated behind-the-meter load forecasts on a near real-time basis at levels of sufficient spatial granularity and accuracy, and incorporate those near real-time forecasts into the market clearing software, it would in theory lead to more accurate price formation and fewer intra-day operating plan

[67] In 2021, there were more than 243,000 individual solar photovoltaic installations in New England representing more than 4.7GW of installed nameplate capacity, the majority of which is behind-the-meter. *See* ISO New England Inc., Final 2022 PV Forecast, at slides 14, 49 (April 28, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/04/final_2022_pv_forecast.pdf.

adjustments. Yet, it remains to be seen whether these so-called "nowcasts" – preliminary irradiance estimates often based on sky imaging – can be procured at sufficient levels of accuracy and at reasonable costs for a geographic area the size of New England.[68]

In addition to the network model and related inputs discussed above, and in light of the growing operational uncertainties in the New England system, the ISO also maintains situational awareness by closely tracking and monitoring fuel availability, especially in the winter season. The ISO currently deploys a variety of processes to maintain situational awareness of fuel availability, including real-time monitoring of pumped storage station reservoir levels, periodic fuel surveys of oil and coal-fired resources, and routine communications with natural gas pipeline operators.[69]

As the resource mix and customer load profiles continue to evolve, there may be opportunities to further supplement the ISO's situational awareness regarding limited energy resources, and more specifically, energy storage resources. For example, the ISO's storage models and communication systems provide the ISO with insights into the available energy and storage capability of energy storage resources (such as battery-electric storage devices and pumped-storage hydroelectric resources) using real-time telemetry,[70] facilitating enhanced situational awareness and dispatchability. Although system operators throughout the country are

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[68] This is an area of active research in the scientific community. *See generally* Lamer, K., Brookhaven National Laboratory, Advanced Solar and Load Forecasting Incorporating HD Sky Imaging: Phase III (June 2022), *available at* https://www.osti.gov/servlets/purl/1873655.

[69] Many of these processes were developed as a result of the need for enhanced situational awareness during instances when natural gas pipelines may be constrained. *See* ISO New England Operating Procedure No. 21 – Energy Inventory Accounting and Actions During an Energy Emergency, *available at* https://www.iso-ne.com/static-assets/documents/rules_proceds/operating/isone/op21/op21_rto_final.pdf.

[70] *See, e.g.*, ISO New England Inc., Operating Procedure No. 14 – Technical Requirements for Generators, Demand Response Resources, Asset Related Demands, and Alternative Technology Regulation Resources, Appendix I – CSF Plant Operator Guide, pp. 5–6, (March 19, 2021), *available at* https://www.iso-ne.com/static-assets/documents/2019/04/op14_appi_rto_final.pdf.

still evaluating how to best operationalize this enhanced situational awareness and dispatchability of storage resources, the increasing development of storage resources in energy markets that provide the ISO with visibility into their real-time energy storage levels likely holds great potential for short-duration system balancing.

Resource Output Coordination and Dispatchability. In its role as the system operator and day-ahead and real-time market administrator, the ISO coordinates unit commitment and dispatch to determine the security-constrained, least-cost means of production throughout the operating day. To determine the optimal resource mix, the ISO coordinates the energy production and delivery from both Non-Dispatchable Resources and Dispatchable Resources.[71]

Non-Dispatchable Resources are not required to respond to electronic Dispatch Instructions from the ISO.[72] Instead, in order to provide energy to the system, a Market Participant with a Non-Dispatchable Resource Self-Schedules by requesting approval from the ISO to bring the generator online. The participant then determines the resource's preferred generation level and communicates that to the ISO. In the event the ISO needs to instruct a participant to change the output of a Non-Dispatchable Resource, it must manually call (*i.e.*, typically by phone) the participant and provide such instructions. Non-Dispatchable Resources are never the "marginal" resource to meet an increment of energy demand, because they cannot

[71] To expand the pool of resources capable of following dispatch instructions, and accounted for in the price formation process, successive tariff revisions have expanded the Dispatchable Resource model to several generating resource types which previously participated only as Non-Dispatchable Resources. *See ISO New England Inc. and New England Power Pool*, Do Not Exceed Dispatch Changes, ER15-1509-000 (filed April 15, 2015); Order Conditionally Accepting, In Part and Rejecting, In Part, Tariff Revisions and Directing Compliance Filing, 152 FERC ¶ 61,065 (2015); Letter Order Accepting DNE Dispatch Compliance Filing, ER15-1509-002 (issued October 1, 2015); *see also ISO New England Inc. and New England Power Pool*, Revisions to Increase Resource Dispatchability, ER17-68-000 (filed October 12, 2016); *Order Accepting Proposed Tariff Revisions*, 157 FERC ¶ 61,189 (2016).

[72] Tariff Section III.1.11.5; Section III.1.11.6. Examples of Non-Dispatchable Resources include Settlement Only Resources (less than 5 MW) and nuclear power generation stations.

be dispatched in real-time to supply an additional MWh of energy. Because they are never marginal, and do not submit priced energy supply offers, non-dispatchable resources cannot set the Real-Time Locational Marginal Price. Instead, they operate as price-takers, generating at their chosen output level regardless of the energy market's price.

A Dispatchable Resource is a resource capable of following electronic Dispatch Instructions issued by the ISO to change the output of the resource in real-time.[73] Dispatch instructions are issued electronically by the ISO, with the instruction directing the resource to move from its current output level to another output level (up or down) known as a Desired Dispatch Point, or establishing the upper bound on a generator's output in the case of a Do Not Exceed (DNE) Dispatch Point instruction.

The DNE Dispatchable Generator rules currently provides a pathway for wind and hydropower Intermittent Power Resources to participate in wholesale electricity markets in a manner that closely resembles that of conventional Dispatchable Generators, but respects certain unique features of such Intermittent Power Resources.[74] Do Not Exceed Dispatchable Generators submit economic energy offers into the Real-Time Energy Market to specify their willingness to provide energy at different price points, in the same manner as other Dispatchable Generators. The ISO then determines the maximum output that can be accepted from the resource based on any existing system reliability constraints, and telemeters a Do Not Exceed Dispatch Point in real time, with the resource free to operate at any output level between 0 MW and the DNE Dispatch Point. This model avoids the need for the ISO to manually request

[73] Tariff Section III.1.11.3.

[74] Although wholesale market participation of DNE Dispatchable Generators generally resembles that of other Dispatchable Generators, DNE Dispatchable Generators generally do not provide reserves or regulation, largely due to their inability to sustain actions for at least one hour.

curtailment of output during times of system constraints, and increases market efficiency by allowing the price formation process to consider the output and energy supply offer prices of DNE Dispatchable Generators. Relatedly, if they have a capacity supply obligation, DNE Dispatchable Generators must submit an offer into the day-ahead market, which further encourages efficient price formation.[75] ISO-NE currently requires that wind and hydropower Intermittent Power Resources larger than 5 MW seeking to participate in wholesale markets use the DNE Dispatchable Generator Model.[76]

As further described in response to question 7.1, the ISO has proposed to expand the DNE Dispatchable Generator model to front-of-meter photovoltaic resources by late 2023. Requiring this enhanced dispatchability will expand the coordination capabilities of the ISO by avoiding the need for manual outreach to resources during times of system constraints, enhance flexibility by enabling real-time dispatch of these resources, and would further encourage efficient price formation by enabling these resources to submit energy supply offer prices that could set the LMP when such a resource is the marginal supplier serving demand from its location.

Markets' Capabilities and Compensation. The third category of current and future system needs is the markets' capabilities to signal, incent, and coordinate investment by private investors in resources' capabilities (over the long-term), and to ensure resources' performance is appropriately compensated and therefore adequately provided (over the short-term). In addition to resources' physical capabilities and ISO informational capabilities, as discussed above, the

[75] Tariff Section III.13.6.1.6.1.

[76] Tariff Section III.1.11.2(e)

market's capability to incent resource investment and compensate for resources' services will require continued attention as the resource mix and customer load profiles evolve.

In a competitive market, prices serve as the mechanism that coordinates private capital and investment. This is true not just for markets and our economy generally, but is critically important to investment in the resource capabilities owned by, and provided by, suppliers in New England's restructured electric power system. If prices reward and remunerate flexibility, then investors and their capital will pursue the development of new (and improved maintenance of existing) flexible resources. Conversely, if the wholesale markets do not reward the resource flexibility needed for a reliable power system, then investors can be expected to deploy their capital elsewhere – and, over time, potentially imperiling system reliability as a consequence. Thus, the capability of the ISO-administered wholesale markets to pro-actively identify, price, and compensate for evolving system needs is essential to both the efficiency and reliability of the power system.

As the resource mix continues to evolve and, with it, the resources' physical capabilities needed to maintain proper standards of reliability, it is essential that the markets properly remunerate well-defined services that ensure such physical capabilities continue to be provided by investors and participants.

More specifically, as the power system and the capabilities needed to assure its reliability continue to evolve, the markets' capabilities to properly incent and coordinate efficient investment will likely mirror the physical resource capability needs discussed above. For example, resources' ramping capability over sustained durations is not expressly priced presently in the ISO-administered markets. This is because aggregate ramping capability in New England has historically been in ample supply relative to the need. As the resource mix evolves and net load ramps become increasingly steep (*c.f.* Figure 7 and Figure 9), it may become necessary to enhance markets by modeling these "inter-temporal" ramping needs – and price these needs explicitly, to ensure they remain voluntarily supplied in a cost-effective way. We further discuss this issue below in the context of Question 5.

Similarly, the ISO does not presently procure or price operating reserves with response times beyond the thirty minute time horizon prescribed by NPCC standards.[77] However, the growth of weather-dependent resources that may experience *unanticipated* and prolonged drop-offs in energy production may warrant new operating reserves of longer duration than existing market products. Such longer-duration reserve capabilities, which we term "replacement energy reserves", may prove more cost-effective than simply increasing the quantities procured of existing short-duration (ten and thirty-minute) operating reserves in order to balance unexpected but sustained changes in weather-dependent generating resources and loads.[78] We further discuss this issue below in the context of Question 5.

Most pressingly, the concerns regarding energy adequacy and the ability of the system to sustain the delivery of electric energy to serve load during extended cold winter weather remains a potentially undervalued system capability by the markets today. As highlighted in its comments at the Commission's September 8th, 2022 New England Winter Gas-Electric Forum, the ISO sees this energy adequacy issue as one of the region's most pressing system needs;[79] the

[77] *See* NERC BAL-002-3 – Disturbance Control Standard – Contingency Reserve for Recovery from a Balancing Contingency Event, Requirement R.1, North American Reliability Corporation, *available at* https://www.nerc.com/pa/Stand/Reliability%20Standards%20Complete%20Set/RSCompleteSet.pdf; NPCC Regional Reliability Reference Directory # 5 Reserve, Northeast Power Coordinating Council, *available at* https://www.npcc.org/Standards/Directories/Directory%205%20-%20Reserve_20200116.pdf.

[78] The ISO has taken due note of the Commission's recent approval of a new, one-hour reserve product in the day-ahead and real-time markets administered by the Southwest Power Pool (SPP), and SPP's rationales therefore. *Southwest Power Pool, Inc.*, 180 FERC ¶ 61,088 (2022).

[79] *See* ISO New England Inc. (*et alia*.), Draft Problem Statement and Call to Action on LNG and Energy Adequacy, Docket No. AD22-9-000 (filed September 2, 2022).

fact that it remains an ongoing concern, despite many efforts to redress it over the past decade, highlights the challenges of identifying and compensating resources and investors for actions that can reduce this reliability risk to a level the New England region finds acceptable over the long-term.

Ultimately, in each of the cases summarized above, pricing the desired services properly and enabling them to be supplied by all physically-capable resources sends a transparent signal regarding their value to investors, incenting their voluntary provision over the short-term – and promoting greater investment in these capabilities over the long-term. Accordingly, a central future (and, in the case of energy adequacy, current) need is to ensure the markets have well-defined services and are capable of properly pricing and compensating for these physical resource capabilities; and using market designs that will ensure they are adequately supplied and tendered at competitive prices. Cognizant of this imperative, the ISO plans to remain proactive in evaluating whether existing market services or products are in need of reform, and whether new services, prices, and products are warranted.

2. *Referring to the system needs identified in answering question 1, how does the RTO/ISO expect those system needs to change over the next five years? Over the next 10 years? What does the RTO/ISO expect the magnitude of those system needs to be in five years? In 10 years?*

The ISO anticipates that the need for additional resource physical capabilities, ISO informational capabilities, and markets' capabilities to incent the former will likely grow over the next five and 10 years. As described above, these needs are driven by increasing net load variability, operational uncertainties, and resource sustainability/energy adequacy concerns.

Load growth and an increasing penetration of weather-dependent resources within the regional resource mix will accelerate these drivers, though precise timelines and impacts beyond those described above would be difficult to predict with any degree of certainty. In the immediate term, as noted above, the region's most pressing concern is energy adequacy during extended cold winter weather conditions. Within the five year time horizon, a primary consideration for the ISO will be the growth of winter peaks in New England, spurred in large part by public policies supporting heating and transportation electrification. Relatedly, the ISO expects a primary consideration for system reliability across the ten year time horizon will be the potential transition from a summer peaking system to a winter peaking system.[80]

2.1 In answering, please provide a high-level overview of the methods used to develop the system needs forecast over the next five years and over the next 10 years. Please provide a high-level discussion of any industry trends that are particularly important to the RTO's/ISO's forecast, such as electric vehicle adoption, behind-the-meter distributed energy resource deployment, increased demand response participation and price-responsive load, growth in transmission infrastructure, and other trends. In evaluating the impact of such industry trends, how does input from efforts by states, local agencies, and utility programs inform that analysis?

As described above, the ISO's CELT Report and Regional System Plan are the primary vehicles through which longer-term load growth and changes in electricity use are forecasted. The CELT Report is developed by the ISO in consultation with state agencies, transmission owners, load serving entities, retail customers, and public interest groups that participate in the Planning Advisory Committee.[81]

The CELT Report and Regional System Plan incorporate the impacts of several material industry trends, including a utility-sponsored energy efficiency program forecast, a behind the

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[80] The transition to a winter peaking system is projected by the common assumptions of the Pathways Study, are consistent with legislatively enacted emission reduction mandates, and are based on the load estimates developed initially in the Massachusetts 80x50 decarbonization study. ISO New England's 2022 Capacity, Energy, Load, and Transmission Study assumes decarbonization strategies which more closely resemble existing policies and programs, and therefore does not project that the system becomes winter peaking within the next ten years. The juxtaposition serves to highlight the inherent uncertainty associated with projecting system conditions on a ten year time horizon.

[81] *See* ISO New England Inc., Planning Advisory Committee Website, *available at* https://www.iso-ne.com/committees/planning/planning-advisory/.

meter photovoltaic forecast (excerpted above), a heating electrification forecast, and a transportation electrification forecast.[82] Figure 10 is excerpted from the 2022 heating electrification forecast, which projects that heating electrification will contribute approximately 500 MW to New England winter peak loads over the next five years, and 1,900 MW to winter peak loads over the next ten years.[83]

Figure 10. 2022 Winter Heating Electrification Forecast Through 2032

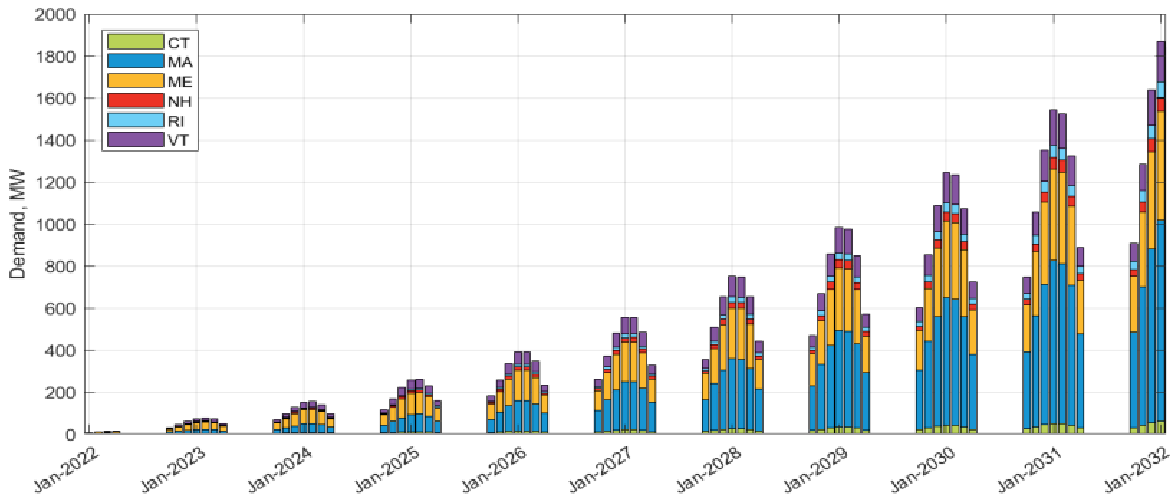

Figure 11 below is excerpted from the 2022 transportation electrification forecast, which projects that transportation electrification will contribute approximately 420 MW to winter peak loads over the next five years, and 1,500 MW to winter peak loads over the next ten years.[84]

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[82] *Supra*, at notes 58– 62.

[83] ISO New England Inc., Final 2022 Heating Electrification Forecast, at 19 (April 28, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/04/final_2022_heat_elec_forecast.pdf.

[84] ISO New England Inc., Final 2022 Transportation Electrification Forecast, at 35 (February 18, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/02/evf2022_forecast.pdf.

Projected transportation electrification contributions to summer peak load are slightly less, due primarily to higher battery efficiency and less vehicle heating needs during the summer.

Figure 11. 2022 New England Transportation Electrification Forecast Through 2032

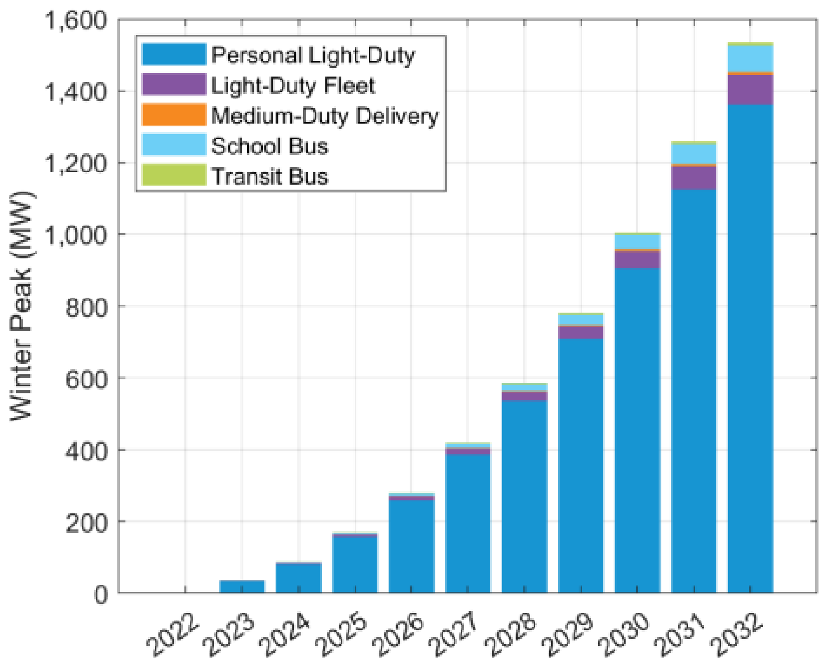

Figure 12 below is excerpted from the 2022 energy efficiency forecast, which projects that newly installed energy efficiency will reduce New England's summer peak demand from what it otherwise would have been by approximately 685 MW over the next five years, and approximately 1060 MW in total over the next ten years.[85] Incremental energy efficiency investments are also projected to result in winter peak demand savings of approximately 660 MW over the next five years, and 1,130 MW over the next ten years.

85 ISO New England Inc., Final 2022 Energy Efficiency Forecast, at 22 (May 2, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/04/eef2022_final_fcst.pdf.

Figure 12. 2022 New England Energy Efficiency Forecast

Summer Peak Demand Savings (MW)							
	NE	CT	MA	ME	NH	RI	VT
2022	134	38	63	9	8	11	6
2023	134	38	63	9	8	11	6
2024	134	38	63	9	8	11	6
2025	134	38	63	9	8	11	6
2026	149	20	103	-2	12	12	4
2027	126	18	87	-2	11	9	3
2028	102	15	71	-3	9	7	2
2029	75	10	55	-3	8	5	1
2030	49	5	39	-4	6	3	0
2031	24	0	24	-5	4	1	-1
Total (2022-2031)	1,061	220	631	17	82	81	33
Average (2022-2031)	106	22	63	2	8	8	3

Winter Peak Demand Savings (MW)							
	NE	CT	MA	ME	NH	RI	VT
2022	126	31	61	9	8	11	6
2023	126	31	61	9	8	11	6
2024	126	31	61	9	8	11	6
2025	126	31	61	9	8	11	6
2026	156	40	93	-2	8	9	9
2027	136	38	80	-3	7	7	8
2028	116	35	67	-3	5	5	7
2029	94	31	54	-4	4	3	6
2030	73	26	41	-5	3	2	5
2031	53	23	29	-5	2	0	5
Total (2022-2031)	1,132	317	608	14	61	70	64
Average (2022-2031)	113	32	61	1	6	7	6

At a high level, New England's extensive investments in energy efficiency and behind-the-meter solar photovoltaics will continue to limit near-term system load growth, but in the longer-term may be offset by investments in heating and transportation electrification that lead to renewed system load growth, particularly during the winter. This may in turn lead to the need for transmission system investments as the system transitions to a winter peaking system.

2.2 What time horizons, such as times of day (e.g., minutes, hours), days, or seasons, are expected to present the biggest challenges with respect to net load variability and uncertainty? Why?

Experience from RTOs/ISOs across the country has shown that net load variability and uncertainty may present challenges to system operation across several time horizons. At present, net load variability associated with declining solar output during the late afternoon and early evening is forecastable with a reasonable degree of certainty in New England. During those instances when net load deviates materially from forecasts, the ISO is able to rely on existing market products and resource capabilities, dispatching the system's balancing resources as needed beyond their day-ahead schedules (*i.e.*, from levels prescribed by that day's operating plan) to reliably serve net load.

When deviations may be localized and transitory in nature, occurring across a time horizon of seconds and minutes rather than hours, the ISO may rely on frequency regulation to maintain the balance between supply and demand. Where deviations may be more substantial, such as an unexpected change in temperature, a drop-off in wind, or a prolonged reduction in solar irradiance, the ISO relies on reserves to maintain system tolerances. However, as the penetration of weather-dependent resources continues to grow, including substantial levels of offshore wind growth, the ISO expects these deviations may present more acute challenges.

The ISO continues to study these issues, and in 2021 conducted a probabilistic analysis of wind speed, photovoltaic irradiance, temperature, and load data in New England to determine which seasons, days, and hours presented the biggest challenges for sustained energy production using weather-dependent energy inputs.[86] The analysis reviewed extended duration adverse weather events based on 20 years of historical hourly data and modeled 1,000 realistically plausible variations of that data, totaling 20,000 years of hourly wind and solar production data, load, temperature, relative humidity, wind speed, and solar irradiance.[87] Figure 13 summarizes certain results of that probabilistic weather analysis. It shows that heat waves sometimes lasted for up to eight days, while cold snaps lasted for up to fifteen days.[88]

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[86] ISO New England Inc., DNV-GL Analysis of Stochastic Dataset for ISO-NE, at 45–54 (February 24, 2021), *available at* https://www.iso-ne.com/static-assets/documents/2021/03/a9_dnv_gl_report_analysis_of_stochastic_dataset_for_iso_ne_rev1.pdf.

[87] *Id*. at 2.

[88] *Id*. at 28. A cold snap or heat wave occurs when the HDD or CDD temperature, respectively, is above the 95th percentile of all heating or cooling degree days.

Figure 13. Summary of Historical Cold Snaps and Heat Waves for New England

Statistic	Cold snap	Heat wave
Average events per year	1.6	0.7
Maximum events per year	8	5
Minimum events per year	0	0
Average event duration per year	3.5	3.8
Maximum event duration per year	15	9
Average degree day temperature	52.2	15.8
Average daily peak load	19,644	24,430
Maximum daily peak load	22,725	28,102

The analysis also identified the potential for lulls in wind and solar photovoltaic power production, defined as production at less than 15 percent of a resources' capacity for three or more days. Offshore wind production lulls occurred approximately 3.9 times each year for offshore resources, lasted as long as eight days, and were more likely and more frequent in the summer than in the winter.[89] Solar photovoltaic production lulls were much less common than wind production lulls, correlated with the winter months only, and lasted up to four days. Although overlap between production lulls and extended duration adverse weather events was rare, such overlaps did occur on a very small percentage of all days.[90]

Although New England does not presently face the significant penetration of large-scale Intermittent Power Resources present elsewhere in the country, it faces unique challenges related to the availability of energy inputs, including natural gas during cold weather, used to balance Intermittent Power Resources' deviations and production lulls when they do occur. Specifically, during potential winter wind production lulls including those which may not be foreseeable,[91]

[89] *Id*. at 46.

[90] Out of a possible 7.3 million days in the dataset, 451 days (0.006%) included an overlap of offshore wind production lulls and a New England cold snap.

[91] Order Directing Reports at P 14 (stating "Meteorological forecast errors can create operational challenges for RTO/ISO operators. For example, on March 26, 2018, SPP experienced a large wind forecast error where the day-

ensuring adequate availability of dispatchable generating resources and related energy inputs will be critical to maintaining a reliable energy system in New England moving forward.

3. *What new system needs not already described, if any, does the RTO/ISO expect to emerge over the next five years? Over the next 10 years? What are the drivers of those new system needs? Are those new system needs quantifiable, and if so, please provide information on how you have quantified those needs.*

Although the above-described system needs are largely spurred by the changing resource mix and customer load profiles, system issues unrelated to those factors are also likely to emerge or grow in importance over the next five and ten years. For example, recent geopolitical tensions have highlighted the need for continued coordination and investment relating to cybersecurity enhancements. The ISO has both long-term and short-term plans to continually address cybersecurity issues, and is actively engaged in related efforts to ensure reliability of the bulk power system and reliable service to customers.[92]

More visibly, recent geopolitical tensions have also impacted global and domestic markets for natural gas in a manner that may likely place an increasing focus on energy affordability and energy adequacy in New England.[93] The ISO remains cognizant of these impacts, and continues to explore opportunities to alleviate energy adequacy and energy

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ahead forecast for wind output was 7,000 MW above the reliability unit commitment forecast. During this event, known in SPP as the "Wind Burn" event, SPP operators committed 54 units out-of-market to replace the unexpected decrease in wind generation and meet reliability needs. SPP stated that the root cause of the forecast error was the poor performance of meteorological forecasts.") (citing Southwest Power Pool Uncertainty Product Whitepaper at 32-34).

[92] The ISO has recently completed or is planning several near-term cyber security enhancements, including a replacement of its identity and access management programming, an update of its security information and event management system, and a refresh of the hardware and software systems that collect network traffic data and feeds that data into network intrusion detection systems.

[93] *See* New England Governors' Letter to Dept. of Energy Secretary Granholm (June 27, 2022) ("While New England has existing programs to support system reliability, the combination of the Russian invasion with a severe cold winter would strain the reliability of the system. Further, the New England states are facing high energy prices and we must work across the federal government to address the funding needed to support our energy consumers."), *available at* https://www.energy.gov/sites/default/files/2022-09/incoming%20-%20Baker%20Lamont%20Mills%20Sununu%20McKee%20and%20Scott.pdf.

affordability issues exacerbated by recent geopolitical tensions.[94]

III. THE ROLE OF ENERGY AND ANCILLARY SERVICES IN A CHANGING SYSTEM

4. *Referring to the changing system needs discussed in questions 2 and 3, to what extent are current RTO/ISO E&AS market products and compensation schemes not designed to procure the resource capabilities needed to meet these expected changing system needs? To what extent are such prices and products unable to adequately compensate the resources possessing the capabilities necessary to meet these expected changing system needs? To what extent does the risk of disorderly retirements of resources with capabilities that are needed to address such needs (e.g., fast ramping dispatchable resources) increase if E&AS markets are not reformed? Why?*

The existing suite of market products and compensation structures has generally served New England well. Nonetheless, the ISO is continually examining whether changes to those products or the introduction of new products may maximize market efficiency.[95] To ensure that prices and products continue to adequately compensate the resources possessing the capabilities necessary to meet expected changing system needs, the ISO is evaluating several potential market enhancements, as further discussed in response to Question 5 below, including an energy imbalance reserve product, a suite of flexible response services, longer-duration "replacement energy" reserve products, reserve zone locational reform, and intertemporal optimization and pricing. Of greater concern is New England's challenges relating to energy adequacy in cold winter conditions, particularly with regard to whether the current markets' "prices and products [are] unable to adequately compensate the resources possessing the capabilities necessary to meet these expected changing system needs."[96]

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[94] *See* ISO New England Inc. (*et alia*.), Draft Problem Statement and Call to Action on LNG and Energy Adequacy, Docket No. AD22-9-000 (filed September 2, 2022).

[95] Tariff Section I.1.3(b) (describing the mission of the ISO as including the creation and sustainment of "markets for energy, capacity, and ancillary services (including Operating Reserves) that are… economically efficient…").

[96] Order Directing Reports at P 36.

Importantly, today's wholesale markets (and enhancements thereto) must contend with market frictions that sometimes stand in the way of resource entry decisions. Although resources tend to retire on schedule once announced by their owners, New England's recent experience has been that new resource do not always enter the market as planned. For example, efforts to ease gas pipeline constraints and to bring HVDC lines to New England's load centers have been consistently ineffectual, not because of market design inadequacies, but instead due to interventions by the courts,[97] regulators,[98] and ballot initiatives.[99] Because of these non-market barriers to entry, as the region continues to engage in its long-term planning exercises, and attempts to better understand the reliability implications of our energy adequacy concerns, it remains unclear whether reforms to energy and ancillary service markets alone will be sufficient to address the region's winter energy adequacy concerns.

With respect to the risks of disorderly retirements, it is difficult to determine the specific timing and likelihood of future retirement decisions for a given generating resource or resource type. However, the ISO remains mindful of the potential for disorderly retirements as it contemplates future market outcomes and potential developments in the energy and ancillary services markets. Figure 14 represents the known and projected existing resource retirements by

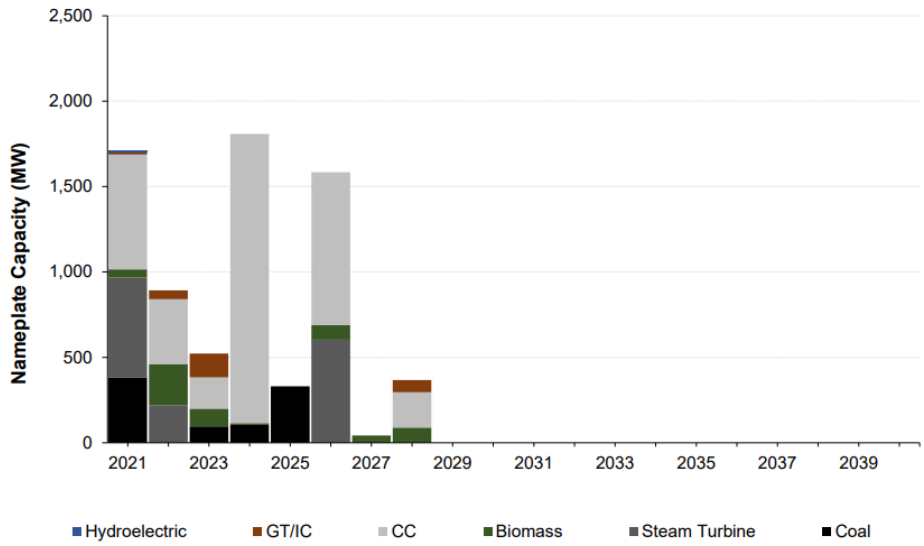
[97] *Engie Gas & LNG LLC v. Department of Pub. Utils.*, 475 Mass. 191, 203-205 (2016) (finding that purchase of gas capacity by electric distribution companies not permitted under restructuring statute).

[98] N.H. Site Evaluation Committee, *Decision and Order Denying Application for Certificate of Site and Facility* (March 30, 2018) (Denying application by Northern Pass Transmission, LLC), *available at* https://www.nhsec.nh.gov/projects/2015-06/orders-notices/2015-06_2018-03-30_order_deny_app_cert_site_facility.pdf

[99] *See* Portland Press Herald, *Three Months After Referendum, NECEC Battles for Survival Amid Legal Challenges*, (February 6, 2022), *available at* https://www.pressherald.com/2022/02/06/three-months-after-referendum-necec-battles-forsurvival-amid-legal-challenges/

resource type that have been announced, or that the ISO's Pathways Study indicates may be expected for economic or other reasons, over the next decade.[100]

Figure 14. Capacity Retirements, Status Quo Policy Approach 2021-2040 (MW)



The majority of these retirements are either combined cycle natural gas, steam turbines, or coal generating facilities. These projections include the retirement of Mystic Generating Station, which is compensated on a cost-of-service basis for winter fuel security reasons through June 2024.[101] The operation of Mystic Generating Station and associated retention of LNG injection capabilities from the Everett Marine Terminal remain front of mind as the ISO and the

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[100] Most of this retired capacity reflects announced retirements, rather than "economic" retirement decisions by units within the study's model. This is because the model finds that it is generally more cost-effective to retain existing capacity than to retire this capacity and replace it with new capacity. *See* ISO New England Inc., Pathways Study: Evaluation of Pathways to a Future Grid, at 46 (April 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/04/schatzki-et-al-pathways-final.pdf.

[101] *ISO New England Inc.*, Compliance Filing to Establish a Fuel Security Reliability Standard, Short-Term Cost-of-Service Mechanism, and Related Cost Allocation for Out-of-Market Compensation, Docket No. EL18-182-000, and Docket No. ER18-2364-000 (filed August 31, 2018); *ISO New England Inc.*, 165 FERC ¶ 61,202 (2018) (accepting compliance filing); *ISO New England Inc.*, 173 FERC ¶ 61,204 (2020) (addressing arguments raised on rehearing).

New England states continue to explore solutions to winter energy adequacy issues.[102] To make substantial progress towards a more durable solution to the region's winter energy adequacy issues, the ISO is engaging our state partners, regional stakeholders, and EPRI to better quantify the risks associated with the region's energy adequacy issues.[103]

5. *Referring to the changing system needs discussed in questions 1, 2, and 3, what planned E&AS market reforms is the RTO/ISO contemplating or other stakeholder processes, if any, is the RTO/ISO conducting related to meeting those expected changing system needs? How will those specific reforms or stakeholder processes help the RTO/ISO meet those expected changing system needs?*

In light of the changing resource mix and customer load profiles, the ISO is contemplating several energy and ancillary service market enhancements, currently in various stages of development and expected to go through the NEPOOL stakeholder process for review, discussion, and refinement in advance of any formal proposals to the Commission.[104] The ISO views these stakeholder processes as critical to ensure that any future proposed reforms are well understood by market participants, and have the benefit of stakeholders' insights and input; therefore, any description of potential reforms and any related timelines provided below are subject to alteration based on those stakeholder discussions and future design progress. Additionally, many of the ISO's projects are multi-year endeavors that are sequenced to align

[102] *See* ISO New England Inc. (*et alia*.), Draft Problem Statement and Call to Action on LNG and Energy Adequacy, Docket No. AD22-9-000 (filed September 2, 2022).

[103] *See Transcript September 13, 2022 Technical Conference Regarding New England Winter Gas-Electric Forum,* Docket No. AD22-9, Tr. 245:9–15 ("[W]here we need to go over the next several months and year is to figure out what is the extent of this problem, and then let's figure out all the market solutions — and if we need some out of market solutions as well, fine — but let's figure out how to solve this problem in the most cost-effective way possible.") (Comments of Me. Pub. Utilil. Comm'n. Chairman Philip Bartlett, II); Tr. 242:22–243:3 ("[T]he ISO has a critical role in helping six states, six sovereigns, have a common conversation about what is resource adequacy and what resources can be used to solve it.") (Conn. Dept. of Energy and Env't Prot. Commissioner Katie Dykes);

[104] Under New England's Regional Transmission Organization arrangements, the rights to make a filing of revisions to the Tariff under Section 205 of the Federal Power Act belong to the ISO. Pursuant to the Participants Agreement, NEPOOL provides the sole Participant Processes for advisory voting on ISO matters, and may join in Section 205 filings.

with software development and human resource constraints. As a result, any deviation from the established timeline of a project can have cascading downstream impacts on that project as well as other projects.

The ISO anticipates pursuing potential market reforms that include, but are not limited to: development of an energy imbalance reserve product in the day-ahead market; procuring and pricing a suite of flexible response services in the day-ahead market; evaluating and potentially developing one or more longer-duration, "replacement energy" reserve products in the day-ahead and real-time markets; reforming the geographic locations for which the ISO procures locational reserves in the energy and ancillary services markets; and enhancing the existing real-time markets to better optimize and price intertemporal resource constraints, allowing the ISO to better model and price limited energy resources and steep net load ramps.[105] Each of these potential reforms is discussed in greater detail below.

Energy Imbalance Reserve. As described earlier, the ISO's current unit commitment and dispatch process begins with a Day-Ahead Energy Market that solves for unit commitment, dispatch, and pricing on an hourly basis, based on *bid-in energy demand* of market participants.[106] After Day-Ahead Energy Market clearing is complete, the ISO then conducts a Resource Adequacy Assessment, based on the ISO's *forecast energy requirement*, to determine whether to commit any additional resources to meet the forecast real-time load and operating reserve requirements for each hour of the following day. If the forecasted real-time load and

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[105] A version of several of these market reforms was initially proposed as part of the ISO's Energy Security Improvements filing. *See ISO New England Inc.*, Compliance Filing of Energy Security Improvements Addressing New England's Energy Security Problems, Docket Nos. EL18-182-000 and ER20-1567-000 (filed April 15, 2020); *ISO New England Inc.*, 173 FERC ¶ 61,106 (2020) (rejecting proposed tariff revisions).

[106] Tariff Section III.1.10.1(d) ("Scheduling encompasses the Day-Ahead and hourly scheduling process, through which the ISO determines the Day-Ahead Energy Market schedule and determines, based on changing forecasts of conditions and actions by Market Participants and system constraints, a plan to serve the hourly energy and reserve requirements of the New England Control Area.").

reserve requirement in a given interval exceeds the physical energy supply that clears in the day-ahead market, the ISO may re-dispatch committed resources, extend the commitment of day-ahead market scheduled resources, or commit new resources as a means of ensuring that the forecast load requirement can be satisfied while ensuring the availability of adequate reserves.[107] This current practice assumes there will be enough energy available from unscheduled capacity that has no day-ahead award to meet the forecast real-time load, whenever there is an "energy gap" between the load cleared in the day-ahead market and the ISO's real-time load forecast for the same hour (*i.e.*, when the latter exceeds the former). The size of this day-ahead "energy gap" in New England can vary widely each day, from none in some hours to more than a gigawatt in other hours.

One approach that could consistently cover any "energy gap" between physical energy supply that clears day-ahead and the system's forecast real-time load, and thus satisfy the energy-load imbalance, would be to establish an Energy Imbalance Reserve. The procurement of Energy Imbalance Reserve could be co-optimized with energy in the day-ahead market; the total quantities of Energy Imbalance Reserve would be *just* the exact amounts necessary to fill the "energy gap" between physical energy supply that clears day-ahead and the forecast real-time load, if greater, each hour of the next operating day. By doing so, the ISO would be able to prepare the system, on a day-ahead basis, to satisfy the forecast real-time load (a reliability requirement of the next-day operating plan) through the competitive market – rather than through existing out-of-market practices after the day-ahead market – and solve the region's long-

[107] For a summary of the requirements that inform the ISO's next day Operating Plan, *see* ISO New England Inc., Reliability Standards Supporting Day-Ahead Ancillary Services Requirements, July 3, 2019 Memo to NEPOOL Markets Committee, at 1–5, *available at* https://www.iso-ne.com/static-assets/documents/2019/07/a4b_iso_memo_reliability_standards_supporting_day_ahead_ancillary_services_requirements.pdf.

standing day-ahead "energy gap".

The ISO has begun stakeholder discussions on an Energy Imbalance Reserve product as part of its Day-Ahead Ancillary Services Initiative, with a goal of filing a market design for Commission review by the end of 2023.[108]

Day-Ahead Flexible Response Services. To enable fast ramping capabilities in the event of system contingencies, the ISO currently procures Ten-Minute Spinning Reserves, Ten Minute Non-Spinning Reserves, and Thirty-Minute Operating Reserves in the real-time energy markets.[109] The ISO also administers a longer-term seasonal (approximately six-month ahead) Forward Reserve Market for the same products. These existing reserve markets, while generally able to satisfy current system needs, have known limitations from the standpoint of incenting resource performance and overall economic efficiency.[110]

Thus, the ISO sees benefit in market enhancements with new products that better encourage resource performance as the resource mix continues to evolve, and that prepare the system on a day-ahead timeframe with the flexibility needed to manage operational uncertainties. Such an enhancement may also rectify a limitation of the ISO's current energy-only day-ahead market, which does not expressly procure or price day-ahead reserves of any kind. One

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[108] ISO New England Inc., NEPOOL Markets Committee Presentation Regarding Day-Ahead Ancillary Services Initiative (October 5, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/10/a07_mc_2022_10_12-13_dasi_presentation.pptx; *see also* ISO New England Inc., NEPOOL Markets Committee Memo Regarding Day-Ahead Ancillary Services Project Scope, Status, and Timeline (April 6, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/04/a05_mc_2022-04-12_day_ahead_ancillary_services_memo.pdf.

[109] Tariff Section III.9; Tariff Section III.10.

[110] Potomac Economics, External Market Monitor, 2020 Assessment of ISO New England Electricity Markets, at 9 (June 2021) (recommending elimination of the Forward Reserve Market), *available at* https://www.iso-ne.com/static-assets/documents/2021/06/iso-ne-2020-emm-report-final-6-18-21.pdf; Potomac Economics, External Market Monitor, 2021 Assessment of ISO New England Electricity Markets, at 32 (June 2022) (recommending implementation of operating reserve requirements in the day-ahead market that are co-optimized with energy), *available at* https://www.iso-ne.com/static-assets/documents/2022/06/iso-ne-2021-som-report-full-report-final.pdf.

approach would be to procure products similar to the aforementioned existing real-time reserve products, but to procure them day-ahead. This model for solicitation and settlement of new fast-start and fast-ramping obligations in the day-ahead market is referred to by the ISO as Flexible Response Services.

As part of its Day-Ahead Ancillary Services Initiative, the ISO is proposing a suite of Flexible Response Service products that resources can offer, in conjunction with the proposed Energy Imbalance Reserve product described above. The ISO has a goal of filing the Day-Ahead Ancillary Services Initiative market design for Commission review by the end of 2023.

Replacement Energy Reserves. Although the ISO currently solicits capabilities to recover from system contingencies through the existing real-time and seasonal forward market for operating reserves, the resources awarded such obligations are only required to sustain operation for a period of one hour.[111] In the event of an energy shortfall of sustained duration, such as a day-ahead cleared resource that is unexpectedly unable to operate for multiple hours, the existing operating reserve resources may not suffice to satisfy the system need for replacement energy. For example, if the system were to experience a sustained, multi-hour unanticipated drop-off in the aggregate output of the system's future offshore wind fleet, the existing operating reserve products may be insufficient to sustain adequate energy output for the duration necessary (that is, until either wind production recovers, or other, offline resources can be committed, startup, and begin delivering replacement energy – a process that can take multiple hours).

One approach that could buttress the system's ability to maintain energy and reserve adequacy during such an event would be to create a market for operating reserves of a longer duration than the existing 10- and 30-minute operating reserve products. That market could

[111] Tariff Section III.1.7.19.1.

procure reserve products that have durations ranging from one to several hours, and different requirements for both response time (*i.e.*, how fast the resource must ramp or startup and deliver its requested energy), and how long its energy output must be sustainable (*i.e.*, potentially for multiple hours, rather than current operating reserves' existing one-hour sustainability requirement).

Although the ISO has previously explored opportunities for a Replacement Energy Reserve coincident with deployment of an Energy Imbalance Reserve and Flexible Response Services, it is not the ISO's present intention to propose Replacement Energy Reserve products as part of the Day-Ahead Ancillary Services Initiative. Instead, the ISO plans to delay development of any market for Replacement Energy Reserves, so that the region may leverage the learnings of design and implementation work conducted during development of the Energy Imbalance Reserve and Flexible Response Services offerings.

Reserve Zone Reform. The ISO currently procures real-time operating reserves on a system-wide and zonal basis.[112] There are four currently defined reserve zones, which include Southwest Connecticut, Connecticut, Northeast Massachusetts/Boston, and the rest of the system.[113] These zones were developed more than a decade ago, and New England's transmission system has experienced significant investment and changes since that time. As a result, the ISO believes it would be appropriate to better align the existing locational reserves procured in the markets with the operational requirements for localized reserves to maintain system reliability.

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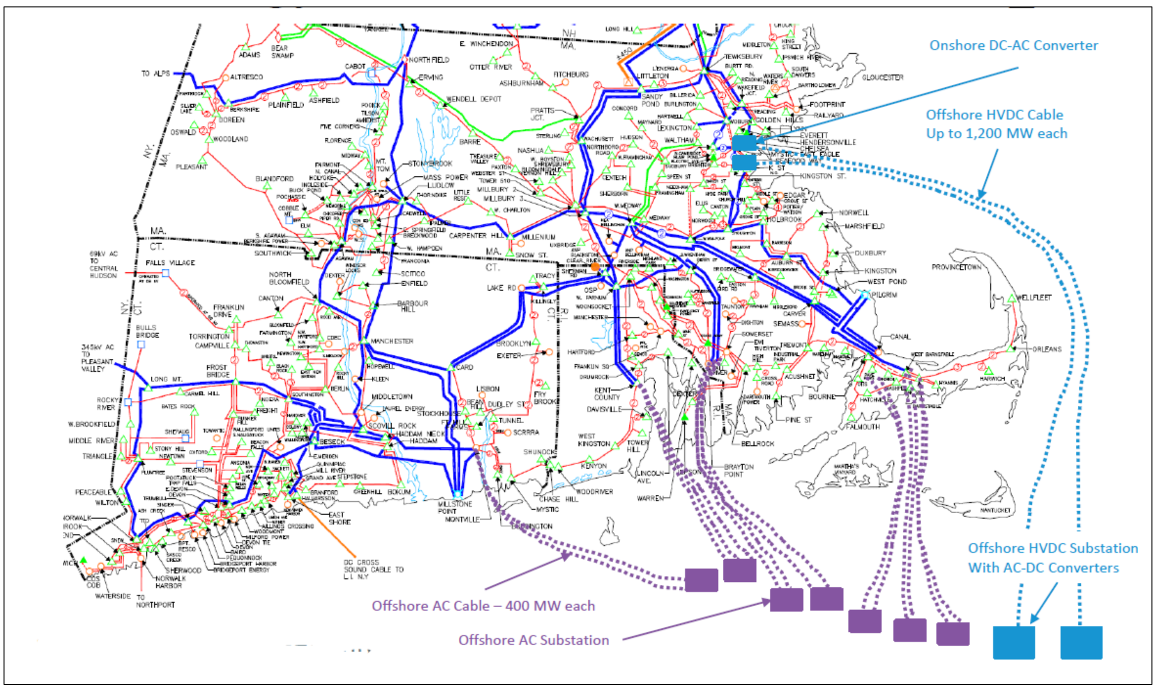
[112] Tariff Section III.9.2.2.

[113] ISO New England Inc., Manual for Forward Reserve and Real-Time Reserve, at 2–3 (October 4, 2018), *available at* https://www.iso-ne.com/static-assets/documents/2018/10/manual_36_forward_reserve_and_realtime_reserve_rev22_20181004.pdf.

Looking forward, as system demand continues to change and the generating mix continues to evolve, the geographic boundaries of reserve zones will likely need to continue to evolve. This is particularly true for those load zones where significant amounts of large-scale Intermittent Power Resources are planned for deployment. For example, Figure 15 was developed as part of an economic study of offshore wind integration in New England and demonstrates potential on-shoring points for transmission lines in a hypothetical future where 8,000 MW of offshore wind is deployed.[114]

Figure 15. Conceptual Application of Offshore AC and DC Cable Technology



Several of the potential locations where submarine transmission cables may reach the grid are within the real-time operating reserve zone currently defined as "rest-of-pool", and for

[114] ISO New England Inc., 2019 Economic Study: Offshore Wind Integration, at 34 (June 30, 2020), *available at* https://www.iso-ne.com/static-assets/documents/2020/06/2019_nescoe_economic_study_final.docx.

which no locational reserves are procured. Similarly, several large wind generation projects located in Maine are proposed in the interconnection queue as well. If significant amounts of Intermittent Power Resources are eventually located in what is currently the rest-of-pool reserve zone, zonal definitions may need to be redrawn to ensure that operating reserves are adequately procured and priced in the locations of the system where they are needed.

Intertemporal Optimization and Pricing. ISO-NE is evaluating opportunities related to a real-time market clearing model that may better account for circumstances where an action by a resource in one interval impacts the efficient dispatch of that same – and other – resources in other intervals. These intertemporal constraints are ubiquitous in electricity markets, but their importance is growing as load profiles change and, concurrently, new technologies with limited energy (such as storage) continue to enter the markets. One common example is resource ramp rates that limit a resource's output change within a certain period: Ramping up the resource now precludes using that same ramping capability later, when the net load ramp may be greater. Thus, resource ramping capability – and, crucially, *when* to deploy that ramping capability – should be *inter-temporally optimized* to dispatch the system in the most economically-efficient manner throughout the operating day.[115]

Another example of intertemporal optimization opportunities relates to the scheduling of resources that have highly limited fuel inventories — such as pondage hydro, or battery-electric energy storage devices — which cannot operate at their full capacity for the entire operating day. As net load conditions or other resources' availability changes in potentially unexpected ways

[115] Zhao, J., (et alia.), *A Multi-Period Market Design for Markets with Intertemporal Constraints*, 35 IEEE Transactions on Power Systems 4 (2020), *available at* https://arxiv.org/ftp/arxiv/papers/1812/1812.07034.pdf; *see also* Technical Conference Presentation of Jinye Zhao, Tongxin Zheng, Jiachun Guo, and Dane Schiro, on behalf of ISO New England Inc., Technical Conference on Increasing Market and Planning Efficiency through Improved Software, Docket No. AD10-12-013 (presented June 21, 2022), *available at* https://www.ferc.gov/media/benefit-evaluation-multi-period-market-clearing.

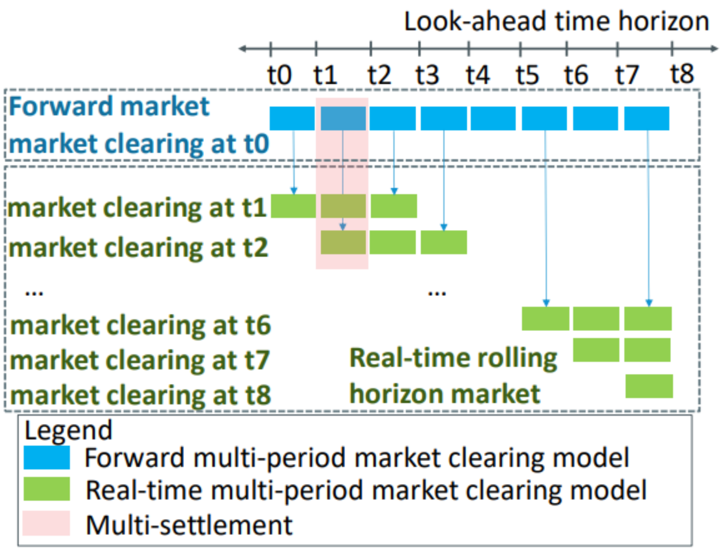
over the course of the operating day, the impact of dispatching these limited-energy resources in one hour on their (depleted) remaining energy stores for later hours must be considered in the *current* dispatch system to maximize their contributions to the grid. As the resource mix continues to evolve, such intertemporal constraints will be increasingly important to account for within the unit commitment and dispatch process.

Day-ahead markets generally schedule and price for all 24 of the following day's hourly intervals simultaneously with one market clearing model. This advance clearing allows the day-ahead market model to account for intertemporal constraints and opportunity costs relating to those constraints when scheduling units and pricing intervals. However, real-time market models, which schedule and price every five minutes, are generally quite limited in their ability to account for intertemporal constraints and related opportunity costs. While some real-time markets use multi-period scheduling to accounts for intertemporal constraints, their models generally limit complexity by increasing time resolution and using a look-ahead horizon of no more than one hour, which limits their effectiveness.

In contrast, a coupled multi-period real-time market clearing and pricing design, one that coordinates current real-time price and dispatch solutions with forward-looking price and dispatch solutions for coming hours, has the potential to better reflect intertemporal constraints like net load ramps, resources' energy limits, and intertemporal opportunity costs. Figure 16 below provides a conceptual representation of this approach to intertemporal optimization.[116]

[116] For additional details regarding a more generalized approach to intertemporal optimization and pricing, *see* Zhao, J., (et alia.), *A Multi-Period Market Design for Markets with Intertemporal Constraints*, 35 IEEE Transactions on Power Systems 4, at 3 (2020), *available at* https://arxiv.org/ftp/arxiv/papers/1812/1812.07034.pdf.

Figure 16. Conceptual Representation: Intertemporal Optimization



This type of market clearing model holds the potential to improve the cost-effectiveness and efficiency of real-time dispatch overall, avoid the computational challenges associated with longer-horizon real-time dispatch calculations, limit uplift payments associated with intertemporal opportunity costs, and improve price formation by reflecting the true costs of intertemporal constraints (*e.g.*, reasonably foreseeable multi-hour net load ramps) in real-time energy prices. The ISO is actively investigating implications of this model, and expects to build upon initial efforts to evaluate the benefits, costs, and operational aspects of its adoption in the coming years, with a formal project expected to begin in 2025.

6. *Over the next five years, and over the next 10 years, how well will existing RTO/ISO market designs together with planned reforms adequately incentivize resource behaviors that will enable the RTO/ISO to meet its changing system needs?*

Through a combination of existing market designs, planned enhancements, and responsive and informed stakeholder processes, the ISO intends to accommodate New England's rapidly evolving resource mix and customer load profiles.

Existing energy and ancillary service markets have been generally sufficient to satisfy the needs of the existing resource mix and maintain reliability to date, and will serve as the foundation for reforms envisioned over the next five years. Developing the day-ahead Energy Imbalance Reserve should improve resource performance incentives, for those resources that the ISO presently relies upon (but does not compensate on a day-ahead basis) to solve the gap between cleared day-ahead physical supply and the system's forecast real-time load each hour of the next operating day. Solicitation of Flexible Response Services in the day-ahead market will similarly improve resource performance by better incentivizing availability and investments necessary to provide energy on short notice the next day (i.e., fast-ramp/fast-start capabilities). The potential creation of Replacement Energy Reserve products may help to preserve grid reliability during events when net load uncertainty results in a significant unanticipated generation shortfall for a duration of several hours or more. Reforming the geographic boundaries used to calculate locational reserves will ensure efficient calculation of required reserve margins, particularly in areas that are now rest-of-pool areas but expect a near-term influx of Intermittent Power Resources, or that have been impacted by the transmission system's continued development over the past decade. A market clearing and dispatch design that coordinates dispatch decisions over a rolling multi-period real-time market has the potential to better accommodate the intertemporal constraints associated with limited energy resources and reasonably-foreseeable, steep net load ramps, enabling the ISO to more efficiently dispatch resources to satisfy energy demand and sustained system ramping needs.

Over the ten year timeframe, the ISO is committed to a process of continuous evaluation and improvement to determine what further market reforms may be necessary to accommodate the changing resource mix and load profile.

6.1 How will existing E&AS market designs together with planned E&AS market reforms create appropriate incentives for existing resources to respond to system needs on operational time horizons (e.g., instantaneously, within five minutes, within 10 or 15 minutes, within one to four hours, etc.), and in the appropriate direction (up versus down)?

The ISO intends to design planned and potential energy and ancillary service market reforms to complement existing markets in a manner that creates the appropriate incentives for existing resources to respond to system needs on the appropriate operational time horizons, and in the appropriate direction.

Markets for regulation, as currently designed, appropriately compensate for changes in output on the *instantaneous and near instantaneous* time horizon, both up and down, that may be necessary to maintain system frequency and therefore reliability. Although the ISO may consider future evaluations of whether the costs and complexities of regulation market reforms are justified by any potential benefits, there is at this time no evidence of a reliability-based need for reforms to the existing regulation markets. This reflects circumstances that may be unique to New England, including the relatively small market for frequency regulation as compared to the overall market for energy and ancillary services, the region's historically high performance on frequency regulation reliability metrics, and the need to evaluate other potential market enhancements (as discussed in response to Question 5 above) prior to undertaking any frequency market reforms.

On average over the past decade, New England's wholesale electric markets have processed between $6-10 billion of transactions annually; this volume has increased substantially recently, and may reach as high as $15 billion for 2022. As demonstrated by Figure 17, the majority of these transactions (by dollar value) have been in the energy market, although over the last five years the cost of capacity have represented a larger portion of overall costs than in prior periods.[117]

Figure 17. New England Historical Electricity Market Values by Market Type

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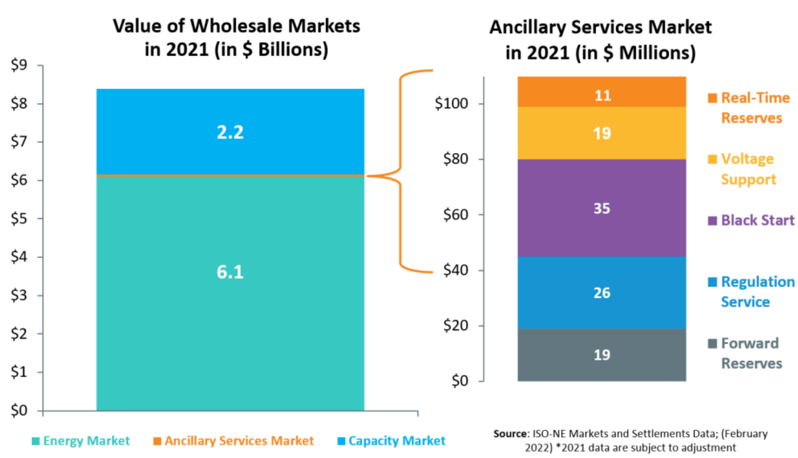
Figure 18. Ancillary Services as a Portion of the Wholesale Electricity Markets



[117] Natural gas futures, geopolitical considerations, and the results of recent forward capacity auctions indicate that this trend may dissipate, at least for the near-term future. *See* Bloomberg, Natural Gas Shortage Fears Buoy US Market as Winter Reserves Lag (August 17, 2022) (describing diminished domestic reserves and strong global demand as leading to significant increases in natural gas futures compared to January 2022), *available at* https://www.bloomberg.com/news/articles/2022-08-17/natural-gas-shortage-fears-buoy-us-market-as-winter-reserves-lag; *see also* ISO New England Inc., Forward Capacity Market Results (describing forward capacity costs as dropping from $4.63/kW-Month in 2021 to approximately $2.60 in 2025), *available at* https://www.iso-ne.com/about/key-stats/markets#fcaresults.

As shown in Figure 18, markets for ancillary services represent a very small portion of the overall wholesale electricity market costs, at approximately $110 million in 2021, compared to $8.4 billion of overall wholesale electricity market costs that year.[118] Ancillary services represented less than two percent of overall wholesale electricity market costs during 2021. Frequency regulation represented only $26 million.

As described above, the ISO is already planning future market enhancements intended to improve resource performance across the *ten-minute to one-hour time horizon*. These reforms include new markets for Flexible Response Services, as well as reforms to the existing real-time reserve market zone definitions. Across *time horizons greater than one hour*, the ISO is evaluating the potential for a replacement energy reserve product, and intertemporal optimization and pricing during the operating day, also described above. When paired with existing reserve markets and unit commitment and dispatch processes, these reforms are expected to satisfy foreseeable upward net load ramping and operational uncertainty needs via Flexible Response Services and replacement energy requirements.

Although downward ramping products may be warranted in other regions with extensive penetrations of Intermittent Power Resources, existing unit commitment and dispatch processes in New England are generally adequate to accommodate downward shifts in net load. Minimum generation events, when the ISO dispatches generation to emergency minimum limits and curtails import contracts due to generation exceeding expected loads, are rare in New England.[119] Such events are expected to continue to remain infrequent for the foreseeable future, particularly

[118] 2021 cost data is preliminary, approximate, and subject to adjustment.

[119] Aside from a minimum generation event that occurred on May 21, 2022, ISO-NE has not had to call a minimum generation event since March 13, 2016.

in light of planned operational reforms that would enhance the ISO's forecasting and modeling capabilities.

6.2 How will existing E&AS market designs together with planned E&AS market reforms create sufficient fixed cost recovery under existing pricing methods (i.e., opportunity costs, shortage pricing, etc.) for resources to make needed investments, remain in service, and continue to offer the capabilities necessary to meet changing system needs?

The ISO's markets endeavor to ensure all costs associated with operating a reliable power system are transparently signaled through uniform prices.[120] As the Commission is aware, this means all providers except the marginal resource earn infra-marginal revenue (*i.e.*, revenue from uniform pricing in excess of their variable cost). Normally, over time, that infra-marginal revenue provides the economically appropriate expected compensation to cover the fixed costs of resource investments. As a general rule, when it is economically efficient for an existing resource to incur such fixed costs, facing those price signals, it will do so. And when it is economically efficient to exit because a resource can no longer recover its fixed costs facing those price signals, it will do so.

However, there can be exceptions to this general property of markets. Broadly, a central rational for the capacity market is to supply the "missing money" that the energy and ancillary service markets fail to remunerate, in order to ensure a reliable system. Generally we expect the markets will most efficiently serve the needs of the system if those capacity market payments are minimized by ensuring the specific products and services our future grid requires are transparently priced, procured, and compensated by energy and ancillary service market designs. Indeed, a central takeaway from the technical conference leading to this order appears to be a broad recognition that such enhancements to the energy and ancillary service markets are

[120] Tariff Section I.1.3(b).

desirable for those very reasons.[121]

6.2.1. How will existing E&AS market designs together with planned E&AS market reforms create an efficient long-run price signal for investment in new resources with the capabilities necessary to meet changing system needs?

The energy and ancillary service market designs and potential reforms endeavor to ensure all costs associated with operating a reliable power system are signaled using uniform, transparent, competitively-determined, product-specific market prices. As a general matter, a continuous focus on developing market designs that transparently price the services that are necessary to meet the changing needs of the system is the optimal way to create an efficient long-run price signal for investment in new resources. In fact, this focus is part of the ISO's mandate, as reflected in our mission statement: "to create and sustain open, non-discriminatory, competitive, unbundled markets … that are (i) economically efficient and balanced between buyers and sellers, and (ii) provide an opportunity for a participant to receive compensation through the market for a service it provides in a manner consistent with proper standards of reliability and the long-term sustainability of competitive markets."[122]

6.3 Regarding E&AS products for which the RTO/ISO is contemplating reforms, to what extent will the reforms ensure that the E&AS products have well-defined demand curves that are rigorously designed to reflect system needs and transparently specify the quantity demanded by the market?

There are both costs and benefits of developing rigorously designed demand curves for ancillary services, which the ISO evaluates when assessing demand curves for any contemplated

[121] Order Directing Reports at P 19 (finding that "RTOs/ISOs and the broader industry are contemplating different E&AS reforms…designed to address specific system needs and market conditions in each RTO/ISO, and no single E&AS market reform that addresses all system needs and all market conditions has been identified," and further recognizing commenter positions that favor "including the value of reforms that direct payments to the resources that actually help to meet system needs instead of paying all resources [and]… ensuring any new or revised products are purchased in quantities and at prices that accurately reflect system needs").

[122] Tariff Section I.1.3(b).

future ancillary service products.[123]

In theory, rigorously-derived engineering-economic demand curves have several benefits. They can price ancillary service products consistent with their expected value in the sense of avoiding a costly loss of load event, or other costly events (*e.g.*, a violation of reliability standards other than a loss of load) and, as a result, they procure ancillary service quantities consistent with those valuations. They also can introduce elasticity (*i.e.*, smoothly changing prices) into product demands for ancillary services, which can attenuate potential market power if supplies are limited and thereby promote competitive outcomes. They can also reduce the importance of any administrative pricing mechanisms for ancillary services, including price caps such as the Reserve Constraint Penalty Factor.[124]

In practice, deriving rigorously-designed demand curves for ancillary services faces a number of significant difficulties. These difficulties are sufficiently challenging that they have materially limited the development of rigorously-derived demand curves (that is, smoothly declining, or "curved," demand curves consistent with engineering-economic theory) for ancillary services across the organized markets. We highlight three of these practical difficulties below.

First, as the Commission noted in the Order Directing Reports, rigorously-designed demand curves for ancillary services are generally formulated in terms of, and therefore based on an explicit assumption about, the economic Value of Lost Load ("VOLL").[125] Data-based estimates of the VOLL from academic and industry studies vary widely, with no clear consensus.

[123] Order Directing Reports at P 22 ("Given the importance of defining demand curves for ancillary service products, further clarification of how such curves will be defined in future E&AS market reforms is needed.").

[124] Tariff Section III.2.7A(c)

[125] Order Directing Reports at P 22 ("While some panelists argued that VOLL should be the basis for all demand curves, others highlighted shortcomings of VOLL and suggested alternative approaches.").

The magnitudes of varying estimates can differ by tens of thousands of dollars per MWh or more.[126] It is unclear how the differences identified in reputable studies should be reconciled.

Moreover, in practice, the VOLL varies over time, duration, with customer class, and a myriad of other potential factors, such as current weather conditions. Commenting on this challenging variation in the VOLL, Potomac Economics, the ISO's External Market Monitor, observed:[127]

> Estimates of the VOLL vary widely based on a range of demand-side factors that include the customer class being served, duration of the load shedding event, season/ timing of the event and geographical location of customers. A meta-analysis of reliability studies by LBNL and DOE estimated that in a one-hour power interruption, a small C&I customer (who may not have installed power back-up systems) could incur a cost per unserved kWh that is nearly 90 times the cost incurred by a residential customer. (See 2015 report on study titled *Estimated Value of Service Reliability for Electric Utility Customers in the United States*.) This study also estimated the cost of interruption for residential customers on a summer morning/ night could be nearly 4 times the cost of interruption on a non-summer evening. VOLL is also known to rise as the length of the outage increases, so a 16-hour long outage can cost an average large C&I customer nearly 22 times what a momentary outage would cost. Hence, VOLL is not a single value and varies considerably.
>
> On the other hand, the VOLL that is implied by capacity market payments (estimated to be over $200,000 per MWh in several studies) is significantly higher than the VOLL across almost the studies [*sic*] (and across all key parameters discussed above). This is because capacity markets set capacity demand curves based on the estimated revenue necessary to satisfy certain reliability standards (rather than an evaluation of demand-side factors).

Reducing such complexities and variation to a single VOLL number for use in an ancillary service demand curve in the wholesale energy and ancillary services markets is

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[126] A standard reference on VOLL estimates, sometimes also called Electric Customer Interruption Cost (or "CIC") estimates, is the periodically-updated meta-survey performed by the Lawrence Berkeley Laboratory. *See* Sullivan, M., (*et. alia.*), on behalf of Lawrence Berkley National Laboratory, *Estimating Power System Interruption Costs: A Guidebook of Electric Utilities* (July 2018), *available at* https://eta-publications.lbl.gov/sites/default/files/interruption_cost_estimate_guidebook_final2_9july2018.pdf.

[127] Potomac Economics, External Market Monitor, 2019 Assessment of ISO New England Electricity Markets, at 46, note 38 (June 2020), *available at* https://www.iso-ne.com/static-assets/documents/2020/06/iso-ne-emm-2019-report-final.pdf.

therefore challenging. In fact, dynamically incorporating this variation in the VOLL into demand curves for real-time ancillary service pricing in an accurate way is apt to be impractical, given the ISO's limited information regarding the specific customer classes and rotating outage durations for which load would be shed by local distribution utilities, in a loss-of-load event.

The second practical difficulty with rigorously-designed demand curves for ancillary services is that they can prescribe quantities that are in conflict with longstanding reliability standards for ancillary services. This problem is not surprising, inasmuch as many longstanding reliability standards were not, to our knowledge, originally developed using the economic theory that underlies rigorously-designed demand curves. Yet the potential conflict between the two can pose difficult regulatory challenges.

As an example, the ISO is subject to minimum real-time operating reserve requirements prescribed by both NERC and NPCC standards.[128] A rigorously-derived demand curve for these ancillary service products could conceivably specify quantities that, at prevailing clearing prices, procure and would therefore maintain in real-time lower amounts of these reserve products than the minimum specified by the mandatory reliability standards. That would put jurisdictional entities, such as the ISO, in a problematic predicament: the ISO would need to either (a) honor the rigorously-derived demand curves' procurement quantities in real-time, but violate the minimum requirements of the reliability standards; or, alternatively, (b) honor the minimum requirements of the reliability standards, in which case it would potentially not satisfy the quantities specified by the rigorously-derived demand curves – thus not procuring and pricing

[128] *See* NERC BAL-002-3 – Disturbance Control Standard – Contingency Reserve for Recovery from a Balancing Contingency Event, Requirement R.1, North American Reliability Corporation, *available at* https://www.nerc.com/pa/Stand/Reliability%20Standards%20Complete%20Set/RSCompleteSet.pdf; *see also* NPCC Regional Reliability Reference Directory # 5 Reserve, Northeast Power Coordinating Council, *available at* https://www.npcc.org/Standards/Directories/Directory%205%20-%20Reserve_20200116.pdf.

the ancillary service according to the defined curves.

We highlight this predicament because presently there is no clear resolution between (a) and (b). This makes it difficult for jurisdictional entities such as the ISO, and its stakeholders, to make progress on developing ancillary service demand curves, in the absence of pro-active guidance from the Commission on how this dilemma should be reconciled.[129]

The third practical difficulty with rigorously-designed demand curves for ancillary services is that they can be exceedingly computationally complex. Deriving a demand curve for a new (or an existing) ancillary service product consistent with rigorous engineering-economic theory involves, among other things, estimating the loss-of-load probability and magnitude associated with each possible reserve quantity. Those probabilities and magnitudes vary dynamically with a wide variety of system conditions, including the generation pattern, resource outage probabilities, correlations among those potential outages, load levels, and other factors. While such calculations can be performed in principle (in offline studies), the ISO does not presently have software systems, models, and tools to do so, and developing such tools could be costly and take considerable time. As a consequence, it is unclear whether the benefits of doing so would exceed the costs, and whether it would be prudent to delay necessary reforms to the energy and ancillary service markets in order to develop such models.

The Commission's question above also inquires as to the ISO's plans to "have well-

[129] We note that in certain non-jurisdictional regions (*e.g.*, ERCOT), operating demand curves have been adopted that are a "hybrid" in which minimum reliability requirements are honored with a 'vertical' portion of a demand curve at the minimum quantity required, and a supplemental 'tail' is added to create a 'curved' section based on analyses that more closely reflects methodologies underlying a rigorously-derived demand curves. *See* Carden, K., and Dombrowsky, A., on behalf of Electric Reliability Council of Texas, Estimation of the Market Equilibrium and Economically Optimal Reserve Margins for the ERCOT Region for 2024, Appendix 1, at 24 (January 15, 2021), *available at* https://www.ercot.com/files/docs/2021/01/15/2020_ERCOT_Reserve_Margin_Study_Report_FINAL_1-15-2021.pdf. Such hybrid approaches may be a practical solution to this predicament, but are essentially selecting alternative (b) to the predicament highlighted above: hybrid approaches potentially procure reserves at quantities inconsistent with VOLL or a rigorously-derived demand curve for the relevant ancillary services.

defined demand curves that are rigorously designed" for future ancillary service products. Because of the significant challenges summarize above, the ISO has not yet identified a general planned path forward on this issue. We would respectfully appreciate the Commission's perspectives on the specific regulatory and VOLL-related issues summarized above, as a means to facilitate future research and potential practical implementations of well-designed demand curves.

6.4 Regarding E&AS products for which the RTO/ISO is contemplating reforms, to what extent will the reforms ensure that the E&AS products direct compensation to resources that contribute to satisfying the particular system need(s) the product is designed to address and not to resources that do not make such contributions?

Efficiently-designed markets require that any firm should be compensated for each system requirement to which it contributes. If a firm's assets and resources do not contribute to a particular requirement or system need for which the ISO's products provide, then it does not receive that compensation.

Consistent with its mission, the ISO undertakes extensive analysis when contemplating and vetting market designs to ensure that the compensation for the products being procured are consistent with this objective. In the context of the energy and ancillary services markets, each resource that is physically capable of contributing to a system constraint (*i.e.*, a product quantity requirement) is paid based expressly on the system's marginal cost of satisfying that constraint. And each resource that does not contribute to that system constraint is not paid the price associated with satisfying that constraint. In this way, the energy and ancillary service products' market design and implementation directs compensation to resources that contribute to satisfying the particular system need(s) the product is designed to address, and do not direct compensation to resources that do not make such contributions. We fully expect that any future energy and ancillary service designs will continue to satisfy this basic market design objective.

The proposed Energy Imbalance Reserve would procure resources' capability to fill any gap between physical energy supply that clears day-ahead and the ISO's forecast of real-time energy demand. The market for Flexible Response Services would be supplied by, and compensate, those resources capable of delivering (incremental) energy within ten- and thirty-minutes of being dispatched. The Replacement Energy Reserve products, if proposed, would be tailored to resources capable of delivering energy within the time limits and for the durations specified by the products' terms; the resources that contribute to providing that service would be compensated for doing so. Each of these proposed reforms, if undertaken, will undergo a rigorous internal evaluation and external vetting process with NEPOOL and NESCOE stakeholders to ensure that all resources that contribute to satisfying the product's demanded quantity are compensated at the same rate for their contributions, and the resources that do not contribute to satisfying the product's demand are not.

6.5 Regarding E&AS products for which the RTO/ISO is contemplating reforms, including reforms to resource eligibility rules, to what extent will the reforms ensure that the E&AS products permit all resources technically capable of providing a product or service to offer to do so?

In the same way that the ISO's extensive evaluation and vetting of potential market designs carefully considers how resources are cleared and contribute to satisfying the products' demand quantity, those same processes are used to ensure that all resources technically capable of providing a particular product or service may offer to do so. It also facilitates innovation in resources' technical capabilities, as resource owners identify new ways to bring novel technologies to market that can meet the system's energy and ancillary service requirements. With respect to the particular energy and ancillary service reforms discussed above, these are based on market designs that solicit a capability, rather than a particular resource-type or fuel input.

7. *Referring to the changing system needs discussed in questions 2 and 3, how does the RTO/ISO expect to alter its operational practices, if at all, in order to successfully manage changing system needs over the next five years and over the next 10 years?*

Although it is difficult to determine with any degree of certainty the specific operational capabilities that will be required by the changing resource mix as far as ten years in the future, the ISO is planning several enhancements to operational practices in the near-term to accommodate the changing resource mix and load profile. These enhancements relate to forecasting customer loads and energy inputs, as well as investments in new modeling tools that will help buttress the ISO's ability to maintain a balanced system with increasingly variable net loads. Like the market enhancements described in response to Question 5, planned timelines for the operational enhancements described below may vary based on software development and human resource constraints that may result from project timeline deviations on a given project.

Forecasting Customer Loads and Energy Inputs. Within the next five years, the ISO is committed to improving its forecasting of wind, front-of-the-meter solar photovoltaics, behind-the-meter solar photovoltaics, and customer loads. As discussed in response to Question 1 above, the evolving resource mix has led the ISO to consider whether photovoltaic resources located in front of the meter should be required to participate as DNE Dispatchable Generators, rather than as Non-Dispatchable Generators. The ISO has considered the potential market efficiency improvements of such a requirement and has determined that applying the DNE Dispatchable Generator model to front-of-the-meter photovoltaic resources is warranted. The ISO has completed stakeholder processes on its proposal and plans to file proposed tariff changes by the end of 2022.

As part of the incorporation of front-of-the-meter solar resources into DNE dispatch, if accepted by the Commission, the ISO will develop a solar forecast platform that will more accurately forecast resource-specific solar power production on a five-minute basis.[130] As part of the proposal, the ISO also plans a revision to the telemetry requirements for affected generators, requiring that solar irradiance figures be submitted to the ISO once every 30 seconds. This increased visibility will aid the ISO in understanding the real-time impacts of solar production.

In addition to the planned DNE enhancements, the ISO is planning several other improvements to its forecasting capabilities that will increase system visibility. For example, as discussed in response to Question 1 above, the ISO currently develops weather forecasts for eight cities in New England, and uses a single behind-the-meter solar photovoltaic forecast with a horizon of seven days. The ISO has committed to augmenting these existing processes, expanding the number of cities used in the forecast from eight to twenty-three, and developing a blended photovoltaic forecast that looks out twenty-one days and is based on the forecast of multiple vendors. The ISO plans to implement these forecasting improvements by the third quarter of 2023.

*New Modeling Tools***.** Within the next five years, the ISO is planning to develop new modeling and operational tools that will help ensure its ability to model resource and system response to system contingencies, new market designs, and adverse weather events.

As described more fully above, the system studies conducted by the ISO, including Solutions Studies and Interconnection Studies, generally assume prevalence of conventional resources on the system for the purposes of modeling how the grid will react in the event of a fault. This approach limits the ability of the ISO to understand how the system and resources may react during future contingency events and other scenarios at locations with a significant

[130] As discussed above, additional enhancements would include improved price formation and reduced administrative burden associated with manual load curtailment.

penetration of inverter-based resources. In order to better understand the likely performance of a resource and the grid during contingencies, localized faults, and other voltage variation events, the ISO has committed to developing the ability to perform electromagnetic transient modeling in the near-term. By the end of 2022, the ISO will begin to standardize an Electromagnetic Transient simulation workflow, develop and deliver training to engineers, and integrate those modeling capabilities into large-scale system studies.

To facilitate modeling and analysis that may underpin some of the market reform efforts described above, the ISO is also investing in the continued development of an Integrated Market Simulator. The Integrated Market Simulator tool is being developed to enhance the ISOs ability to quantify the potential outcomes of market design changes under consideration by the ISO, as well as potential changes in system supply and demand conditions. When completed, the tool will provide for enhanced modeling of both day-ahead and sub-hourly pricing and dispatch, and will be useful for quantitatively modeling market-clearing outcomes for the above-described day-ahead and ancillary service market reforms. The Integrated Market Simulator, and associated modeling capabilities, will be undergoing development work through 2023.

As described in response to Question 1 above, the ISO has partnered with the EPRI to enhance modeling capabilities related to operational energy-security risks associated with adverse weather events in New England.[131] The potential impact of low probability but high impact events, including extended duration cold-spells, have long been a cause for concern for system reliability. Through its work with EPRI, the ISO has committed to modeling extreme weather based on historical and projected climate data, development of a probabilistic risk model

[131] *See* ISO New England Inc., Operational Impact of Extreme Weather Events: Energy Security Study Performed in Collaboration with EPRI, Presentation to the NEPOOL Reliability Committee (July 19, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/07/a06_operational_impact_of_extreme_weather_events.pptx.

that will account for weather-related limitations on the availability of generating resources, and the potential adaptation of the ISO's 21 day forward-looking energy forecast to incorporate the results of those models and quantify the risks associated with the identified weather events.

7.1 How does the RTO/ISO expect to meet challenges related to forecasting customer loads and variable energy resource outputs?

Building on its already robust suite of forecasting capabilities, the ISO is making extensive near-term investments in the ability to accurately forecast customer loads and variable energy resource outputs, as described in response to Question 7 above. As the resource mix and customer load profiles continue to evolve, the ISO will continue to explore new forecasting opportunities, including those identified as worthy of consideration in response to Question 1 above. Whether the ISO expects to alter current practices beyond those planned alterations described in response to Question 7 will depend on a future balancing of potential benefits against any incremental costs and administrative burdens associated with those alterations.

7.2 What model improvements, new operational tools, refinements to existing operational practices, or market software enhancements, if any, does the RTO/ISO expect to develop and/or deploy?

As described in greater detail above, the ISO expects to build upon its existing modeling abilities with the near-term development of enhanced inverter-based resource modeling capabilities, an Integrated Market Simulator, and modeling capabilities associated with operational energy adequacy risks during extended duration adverse weather events.

8. *Beyond the reforms discussed in answering questions 4-7, what other reforms to current RTO/ISO E&AS market rules may be required in the future given the RTO's/ISO's expected changing system needs and shortcomings of current E&AS market designs? Why? For example, are changes to resource eligibility rules for ancillary services or uplift policies expected to be necessary?*

In response to Question 1, a broad array of resource performance capabilities are described as potentially necessary in the future based on the changing resource mix and evolving customer load profiles. If the ISO determines that one or more performance capabilities is necessary, corresponding market reforms may be warranted. However, the cost and complexity associated with any proposed reform would be weighed against the anticipated need for that capability, and the limitations of existing compensation mechanisms to address the need. The ISO is committed to a process of continual market improvement and stakeholder engagement, with the ultimate goal of ensuring a measured and cost-effective approach to facilitating the clean energy transition, and a supporting evolution of resource performance capabilities consistent with the pace of the changing resource mix and customer load profiles.

IV. REFORMS BEYOND MARKETS FOR ENERGY AND ANCILLARY SERVICES

9. *For RTOs/ISOs that administer a capacity market, what capacity market reforms, if any, is the RTO/ISO considering to meet expected system needs in the future? For RTOs/ISOs that do not administer a capacity market but rely on a different resource adequacy construct, what reforms, if any, is the RTO/ISO considering to that construct to meet changing system needs?*

In addition to markets for energy and ancillary services, New England relies on a Forward Capacity Market to send price signals that induce economically efficient entry, retention, and exit of resources to meet the region's resource adequacy requirement.[132] Two major and ongoing reforms to the Forward Capacity Market are the recently approved transition away from the Minimum Offer Price Rule (MOPR) and the ongoing development of a new

[132] *ISO New England Inc. & NEPOOL Participants Comm.*, 155 FERC ¶ 61,023 at P 23 (2016) ("The Commission has sought to ensure that capacity prices are at a just and reasonable level, sufficient to incent economically-efficient existing resources to stay in the capacity market and new resources to enter, so as to enable ISO-NE to meet its reliability requirements.").

Resource Capacity Accreditation methodology, both of which are described below. In addition to these reforms, the ISO continues to further explore future opportunities for capacity market structures also that may more efficiently serve the needs of New England. These considerations are also described below.

Minimum Offer Price Rule Transition. To identify and mitigate potential exercises of market power by market participants, the Forward Capacity Market uses a MOPR.[133] To ensure market participants are unable to artificially lower capacity prices, the MOPR imposes an offer floor price review on all new capacity resources that seek to offer below Tariff-based price 'triggers'.[134] These offer review trigger prices are intended to reflect the competitive cost of new entry, net of the competitive market revenues a resource would be expected to receive (for example, revenues from the ISO's energy and ancillary markets), but do not reflect out-of-market revenues. As applied, the MOPR may limit the ability of a resource receiving out-of-market revenues to clear in the Forward Capacity Market, including resources receiving out of market revenues pursuant to state-sponsored resource procurements.

In recent years, state-sponsored support of renewable energy and other resources have proliferated in New England, serving as a key driver of the changing resource mix. In light of this changing resource mix, the ISO concluded that continued application of the MOPR beyond the near term would have limited the ability of the Forward Capacity Market to account for their entry, leading to the potential for inefficient overbuild. On March 31, 2022, after an extensive stakeholder process the ISO and NEPOOL jointly filed, and the Commission later approved, Tariff amendments providing for a graduated transition away from New England's MOPR over a

[133] The MOPR is contained in Section III.A.21 of Appendix A to Market Rule 1.

[134] Tariff Section III.A.21.1.

two year period.[135]

Resource Capacity Accreditation. The decision to transition away from the Minimum Offer Price Rule was directly precipitated by the changing resource mix, but the timeline for that transition was also impacted by plans to reform the manner in which the ISO accredits resources for their capacity contributions. The Forward Capacity Market currently attributes capacity based on heuristics, whereby a set of practical rules are employed to approximate a resource's contribution to meeting an Installed Capacity Requirement, which result in a Qualified Capacity value for that resource.[136] For example, the Qualified Capacity of Intermittent Power Resources is generally based on historical median output in a predetermined set of hours.[137] In contrast, the Qualified Capacity of an existing non-intermittent generation resource is generally based on the resource's demonstrated maximum output capability and adjusted ambient air temperature.[138]

As the resource mix continues to evolve, a more sophisticated approach to capacity accreditation than the current heuristics-based approach is necessary. Instead, using a marginal reliability contribution methodology that accredits resource capacity values based on their ability to reduce expected unserved energy, whenever it is expected to occur, would likely more

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[135] *ISO New England Inc. & NEPOOL Participants Comm.*, 179 FERC ¶ 61,139 (2016).

[136] The region's Installed Capacity Requirement is determined based on a Loss of Load Expectation that non-interruptible customers will be disconnected as a result of resource deficiencies no more than 0.1 day each year. There is both a system-wide requirement, as well as related zonal requirements. *See* Tariff Section III.12.1.

[137] *See, e.g.*, Tariff Sections III.13.1.2.2.2.1 and III.13.1.2.2.2.2. Summer capacity values for Intermittent Power Resources are based, primarily, on the resource's net output in hours ending 1400 through 1800 each day of the summer period (June through September). Winter capacity values are based, primarily, on hours ending 1800 and 1900 each day of the winter period (October through May); *see also* ISO New England Inc., Installed Capacity Requirement Reference Guide, at 18 (September 15, 2021) ("The QC of an Intermittent Power Resource is based on the resource's historical median output during the Summer Intermittent Reliability Hours and Winter Intermittent Reliability Hours averaged over a period of five years."), *available at* https://www.iso-ne.com/static-assets/documents/2021/06/icr-reference-guide.pdf.

[138] *See, e.g.*, Tariff Section III.13.1.2.2.1.2; *see also* ISO New England Inc., Installed Capacity Requirement Reference Guide, at 17–18 (September 15, 2021), *available at* https://www.iso-ne.com/static-assets/documents/2021/06/icr-reference-guide.pdf.

accurately accredit resource capacity as hours with expected unserved energy become less predictable (*e.g.*, move away from the traditional summer peak load hours). As is addressed in more detail below, the ISO is exploring a revised capacity accreditation methodology with stakeholders and plans to file design changes with the Commission sometime in the third or fourth quarter of 2023.

Future Considerations. In addition to the MOPR transition and Resource Capacity Accreditation reforms, the ISO continues to evaluate opportunities for future capacity market improvements. In its 2021 Assessment of New England's Electric Markets, the ISO's External Market Monitor recommended that the ISO transition away from the current forward capacity auction model. Instead, the External Market Monitor recommended transitioning towards a prompt capacity auction conducted on a seasonal basis ahead of each summer and winter period, using capacity market demand curves that reflect the marginal value of capacity in each season.[139] While the ISO is still in the early stages of evaluating the merits of such a significant change to the Forward Capacity Market design, it is clear that any transition to a materially different capacity market structure will require extensive resources, evaluation, and a collaborative stakeholder engagement process prior to the development of any such reforms.

9.1 What new capacity accreditation methods, if any, is the RTO/ISO considering for its resource adequacy processes? How will such new capacity accreditation methods help the RTO/ISO satisfy expected changing system needs?

As described above, the ISO is continuing to evaluate the appropriate Resource Capacity Accreditation framework for New England. The ISO currently is working to develop a Marginal Reliability Impact ("MRI") methodology, which will take into consideration resources' operating

[139] Potomac Economics, External Market Monitor, 2021 Assessment of ISO New England Electricity Markets, at 32 (June 2022) (recommending implementation of a prompt seasonal capacity market), *available at* https://www.iso-ne.com/static-assets/documents/2022/06/iso-ne-2021-som-report-full-report-final.pdf.

characteristics such as intermittency, fuel (or other energy) limitations, and forced outages in determining their reliability contributions.[140] As envisioned, calculation of reliability contributions would be based on the MRI principle and a probabilistic resource adequacy assessment method. Under such an approach, resource reliability contributions to the system generally depend on the expected performance during hours associated with expected unserved energy, which in turn are determined by the resource mix and the system demand.[141] A similar methodology has been recommended by the ISO's External Market Monitor, Potomac Economics.[142]

To inform its capacity accreditation design, the ISO held two technical meetings in 2021, and began stakeholder discussions on design changes in June 2022. After a thorough stakeholder process to collect input and feedback on the proposed changes, the ISO intends to submit a revised accreditation approach to the Commission before the end of 2023. A new resource accreditation framework will better align resources' capacity values with their respective contributions to resource adequacy during hours when capacity is most needed, that is when the system is expected to be at risk of having unserved energy or is observing expected unserved energy. This will be particularly helpful as the changing resource mix makes it more likely that the need for capacity may be the greatest outside of the historical peak load window.

[140] *See* Motion to Dismiss and Answer to Complaint of ISO New England Inc., Docket No. EL22-42-000 (Apr. 14, 2022), supported by testimony from Tongxin Zheng at pp. 5-6.

[141] *Id*. at p. 6.

[142] *See* Potomac Economics, *2020 Assessment of the ISO New England Electricity Markets*, p. 13 (June 2021), at https://www.potomaceconomics.com/wp-content/uploads/2021/06/ISO-NE-2020-SOM-Report_Final.pdf. ("[W]e recommend that the ISO develop capacity accreditation rules based on each resource's marginal reliability value.").

9.2 What new products that value flexible attributes, if any, should be introduced in resource adequacy constructs, including capacity markets? Would such a change support adequate price signals for the investment and/or retention of resources with the capabilities needed to address emerging needs?

Although the need for flexible attributes will undoubtedly continue to grow in importance as the resource mix and system load profile continue to evolve, the ISO does not view capacity or other long forward markets as favored mechanisms for valuing flexibility. For example, as discussed in greater detail above, the ISO currently administers a market for forward reserves that runs approximately six months in advance of when those reserves may be called upon in the real-time reserve market. However, the ISO is planning to propose elimination of these markets, consistent with deployment of its Flexible Response Service products. This planned elimination of forward reserves is because administering such a market at the same time as the market for forward reserves would be problematic and inefficient, and because the Flexible Response Service products will be superior in two ways. First, these products are consistent with the next day operating plan. Second, this design produces more efficient incentives for resources to be available to provide energy in real-time when needed. Potomac Economics, the ISO's External Market Monitor, has recommended the elimination of the existing Forward Reserve Market, in part for this reason.[143]

Similarly, it is critical to ensure that capabilities relating to resource flexibility are remunerated appropriately, which is most accurately determined in the day-ahead and real-time markets. That is where prices that reflect the costs of supplying these capabilities, and the system's demands for them, can be calculated properly as actual supply and demand conditions

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[143] Potomac Economics, External Market Monitor, 2020 Assessment of ISO New England Electricity Markets, at 11 (June 2021) (recommending elimination of the Forward Reserve Market), *available at* https://www.iso-ne.com/static-assets/documents/2021/06/iso-ne-2020-emm-report-final-6-18-21.pdf.

manifest for each hour of the operating day.[144] Such a finely-tuned and economically-logical compensation structure becomes difficult to administer within the capacity market construct, which provides for a single product and sets prices three years in advance of the performance period – when the system's actual demand for, and value of, flexibility is difficult to quantify with any accuracy.

10. What reforms beyond those to the RTO's/ISO's tariff(s) does the RTO/ISO believe might be needed to address expected changing system needs?

Beyond the Tariff-based reforms described elsewhere in this report, the ISO believes reforms to NERC standards, continued coordination between neighboring RTOs, enhanced coordination between transmission and distribution utilities, and continued attention to natural gas and electric market coordination may be warranted to address the changing resource mix and system load profile, as further described below.

10.1 What reforms to reliability requirements, such as reforms to NERC standards, might be necessary?

In November 2020, the North American Electric Reliability Corporation's Board of Trustees was presented with a whitepaper entitled "Ensuring Energy Adequacy with Energy Constrained Resources."[145] This whitepaper catalyzed the formation of NERC's Energy Reliability Assessment Task Force. That task force developed a standard authorization request, submitted to NERC in April 2022, that proposes development of a standardized planning framework for, and plans to address adverse bulk electric system impacts relating to, fuel

[144] *See Transcript September 14, 2021 Technical Conference Regarding Modernizing Electricity Market Design: Energy and Ancillary Services in the Evolving Electricity Sector*, Docket No. AD21-10-000, Tr. 249:16–253:10.

[145] North American Electric Reliability Corporation, *Ensuring Energy Adequacy with Energy Constrained Resources* (December 2020), *available at* https://www.nerc.com/comm/RSTC/ERATF/ERATF%20Energy%20Adequacy%20White%20Paper.pdf.

adequacy issues.[146] For example, in the same way reserve margins are uniformly defined according to a pre-defined level of contingency events, energy adequacy planning may warrant similarly pre-defined assumptions and standards. These standards could be agreed upon across balancing areas, to ensure co-reliance on neighboring supply does not succumb to incorrect assumptions that lead to a shared energy adequacy shortcoming. The ISO has actively been working with the NERC, other balancing authorities, and other interested stakeholders in furtherance of such a standard, and will continue to do so as the changing resource mix may necessitate.

10.2 What reforms to policies for coordinating operations with adjacent balancing authority areas in both RTO/ISO and non-RTO/ISO regions might be necessary?

The ISO views coordination and communication between adjacent balancing authorities as a key strategy for ensuring bulk electric system reliability. To ensure adequate coordination and communication, ISO-NE, NYISO, and PJM, pursuant to the Amended and Restated Northeast ISO/RTO Planning Coordination Protocol,[147] develop an annual Northeastern Coordinated System Plan.[148] In addition to development of the Northeastern Coordinated System Plan, the ISO is working with adjacent balancing areas to ensure reliability assessments are coordinated between areas to harmonize interchange assumptions, such as through the development of NERC standards, as described above. Aside from these continuing efforts, the ISO does not foresee coordination with adjacent balancing areas in the Northeast as requiring

[146] North American Electric Reliability Corporation, Member Representatives Committee Pre-Meeting Informational Session, Standard Authorization Request, at 20–30 (January 12, 2022), *available at* https://www.nerc.com/gov/bot/MRC/Agenda%20Highlights%20nad%20Minutes%202013/MRC-Informational-Session-Agenda-Package-01-12-22--.pdf.

[147] Amended and Restated Northeast ISO/RTO Planning Coordination Protocol, *available at* https://www.iso-ne.com/static-assets/documents/committees/comm_wkgrps/othr/ipsac/rto_plan_prot/planning_protocol.pdf.

[148] 2021 Northeastern Coordinated System Plan (July 22, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/07/2021_ncsp_pjm_nyiso_iso_ne_final.pdf.

reform in the near future.

10.3 What actions should the Commission consider taking to encourage coordination between the electricity transmission and distribution system operators in order to address challenges arising from limited visibility into distribution-connected resources?

Although the ISO does not provide direct recommendations relating to transmission and distribution coordination at this time, it does see value in enhanced visibility into the loading, flows, generation, and voltage levels that may be present on the distribution system and can impact the bulk electric system. For example, electrical faults on the distribution system can adversely impact resources in the bulk power system, and resources that are supplying services in the wholesale markets (*e.g.*, tripping a generating asset offline due to voltage variations, even if a generator's host distribution system element remains energized). With enhanced distribution system loading and voltage visibility, the ISO may be able to better anticipate the potential unavailability of that resource under certain system conditions, and the duration of that potential unavailability.

The Commission guidance in Order No. 2222 requiring rules for coordination with distribution system operators can be viewed as an important piece of an ongoing discussion around this enhanced coordination. While still pending before the Commission, the ISO views the compliance filing's proposed rules related to coordination of registration and operations as key next steps in this continuing discussion.[149]

Another potential opportunity for transmission and distribution coordination to enhance visibility and wholesale market participation relates to cost allocation. Wholesale market and related costs, other than energy, are generally allocated to load serving entities in one of two

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[149] ISO New England Inc., Order No. 2222 Compliance Proposal, at 36–38 (February 2, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/02/order_no_2222_filing.pdf.

ways, depending on the service or cost at issue. For example, the method for allocating ancillary service costs varies by service. Forward reserves, real-time reserves, regulation service, and regulation capacity are generally allocated based on a participant's real-time load obligation, with forward reserves only allocated to on-peak hours. Charges and payments associated with Support and Black Start system restoration, as well as the costs of the Pooled Transmission Facilities themselves, are recovered via a Regional Network Service charge.[150] Currently, these Regional Network Service costs are allocated based on a network customer's share of the local network's hourly load in the hour in which the local network's aggregate load is at its maximum for the month (*i.e.*, the monthly peak).[151]

Such an allocation may encourage behind-the-meter load shifting during monthly peaks to reduce the share of costs allocated to an individual customer or load serving entity, but not necessarily overall system costs. These load shifting strategies, if pursued at a broad enough scale, may have the potential to impair system visibility, and may require load forecast adjustments to adequately predict system peak impacts. As the resource mix and customer load profiles continue to evolve, transmission and distribution system operators may need to coordinate regarding whether current cost allocation methodologies adequately match cost causation, and whether there may be opportunities to provide greater visibility and predictability related to distribution system load shifting during monthly peaks while also encouraging wholesale market participation by these load shifting resources.

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[150] The Regional Network Service Charge recovers costs associated with serving Regional Network Load, including infrastructure costs, reliability costs, and administrative costs. *See* ISO New England Inc., June 2022 Monthly Regional Network Load Cost Report (August 18, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/08/2022_06_nlcr_final.pdf.

[151] This emphasis on monthly peak load shifting is also impacted by capacity costs, which are allocated monthly based upon a wholesale customer's share of the region's consumption at the time of the system hourly peak during the prior (June-May) year.

10.4 What reforms to other services within the Commission's jurisdiction, such as natural gas transportation services, should the Commission consider in order to improve operational flexibility in the fuel supply?

The ISO and regional stakeholders have extensively studied, and are continuing to evaluate, opportunities for an improved approach to the region's seasonally-constrained natural gas supply.[152] To date, these efforts have resulted in a number of market enhancements and operational and improvements at the ISO, including the development of industry-leading communication and coordination protocols, allowing for expanded situational awareness regarding fuel availability.[153] As the system evolves over the next 5-10 years, enhanced coordination between the gas and electric markets is an area that may benefit from continued attention and improvement.

11. While the questions in this order have asked about a five-year and 10-year time horizon, what activities, if any, is the RTO/ISO undertaking to consider changing system needs that could materialize beyond the 10-year time horizon?

Although planning beyond the ten year time horizon with any certainty is difficult, the ISO has engaged in a several recent long-term planning activities to better anticipate future system needs resulting from the changing resource mix and customer load profiles. Many of the projections associated with these long-term planning exercises are discussed above and include the Pathways Study, the Future Grid Reliability Study, and the 2050 Transmission Study. These

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[152] In light of these ongoing efforts, the ISO makes no recommendations regarding natural gas transportation services or related reforms at this time. *See generally* ISO New England Inc., 2023 Annual Work Plan, Presentation to the NEPOOL Participants Committee, at 7–9 (October 12, 2022) (describing the analysis being jointly conducted by EPRI and the ISO regarding the operational impacts of extreme weather events, as well as a potential energy adequacy anchor project that may incorporate the results of that analysis), *available at* https://www.iso-ne.com/static-assets/documents/2022/10/2023_awp_final_10_12_22.pdf.

[153] *See* ISO New England Inc., Scope of Procedure SOP-RTMKTS.0050.001 – Perform Electric Gas Coordination, *available at* https://www.iso-ne.com/static-assets/documents/2018/06/sop_rtmkts_0050_0011.pdf; *see also* ISO New England Operating Procedure No. 21 – Energy Inventory Accounting and Actions During an Energy Emergency, *available at* https://www.iso-ne.com/static-assets/documents/rules_proceds/operating/isone/op21/op21_rto_final.pdf.

studies indicate that beyond the ten year horizon, the system will increasingly peak during the winter,[154] and in some projected scenarios may require extensive reserve margins to accommodate the level of renewables necessary to achieve the long-term emission reduction goals of the New England states.[155]

12. If RTO/ISO market design changes beyond the RTO/ISO's planned E&AS market reforms discussed in answering questions 4-7 are necessary to manage expected changes in system needs, how can the Commission best assist RTOs/ISOs and their stakeholders in reforming their markets in the future?

Although the ISO does not at this time envision near-term reforms beyond those which are already described above in response to Questions 4-7, we anticipate that the continuous improvement process at the core of our market assessment and stakeholder processes will identify potential market enhancements responsive to the changing resource mix and customer load profiles beyond those foreseeable on the existing time horizon. To that end, we appreciate the Commission's proactive inquiry in this Order, while also remaining mindful of the pace, breadth, and multitude of ongoing proceedings and proposed rulemakings.[156] The Commission's

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[154] *See* ISO New England Inc., 2050 Transmission Study Preliminary N-1 and N-1-1 Thermal Results, Presentation to the NEPOOL Planning Advisory Committee (March 16, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/03/a4_2050_transmission_study_preliminary_n_1_and_n_1_1_thermal_results_presentation.pdf.; *see also* ISO New England Inc., 2050 Transmission Study Updated Results and Approximate Duration of Overloads, Presentation to the Planning Advisory Committee (July 20, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/07/a7_2050_transmission_study_updated_results_and_approximate_frequency_of_overloads_1.pdf.

[155] ISO New England Inc., 2021 Economic Study: Future Grid Reliability Study Phase 1, at 2 (stating "the reserve margin – i.e., how many extra resources are needed to keep the system reliable in times of stress – may need to increase by an order of magnitude by 2040 (i.e., from 15% to 300%).") (July 29, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/07/2021_economic_study_future_grid_reliability_study_phase_1_report.pdf.

[156] *See Transcript September 13, 2022 Technical Conference Regarding New England Winter Gas-Electric Forum*, Docket No. AD22-9, Tr. 264:24–265:5 ("[t]he pressures being put on [the ISO] are growing and I think that making sure that they have the budgets and the adequate staff to keep up with the pace of change that's going on right now is critical. I think we are going to be asking them to do more, not less.") (Comments of Mass. Dept. of Pub. Utilil. Chairman Matthew Nelson).

continued agility and responsiveness to future market filings submitted by the ISO will be to the benefit of New England's wholesale electricity markets, and the region more broadly.

The ISO also appreciates the Commission's willingness to recognize that the unique resource mix, load profile, and existing market structures present in each ISO/RTO region militate against a one-size fits all approach to future potential energy and ancillary service market reforms.[157] Experience suggests that each ISO possesses critical expertise to contribute to the development of specific reforms necessary to meet their respective region's unique needs. A uniform approach to satisfying future system needs may not result in reforms adequately tailored to a particular region's optimal balance between the benefits of reform and costs associated with market complexities.

Finally, the ISO appreciates the on-going opportunity to receive input and guidance from the Commission and its Staff prior to the formal submission of Tariff change proposals, through pre-filing meetings and public technical conferences and forums. To that end, the ISO respectfully stresses the importance of receiving final orders in a timely manner on open dockets, to avoid protracted proceedings that prevent open dialogue with the Commission and its Staff due to the application of the Commission's *ex parte* communications rule.[158]

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[157] Order Directing Reports at PP. 4–5. ("Panelist discussions at the E&AS conferences and post-conference comments did not identify a clear generic or "one-size-fits-all" solution to modernizing E&AS markets to meet changing system needs. Rather, panelists stressed that system needs will differ significantly across RTOs/ISOs, in large part due to differences in resource mixes across RTOs/ISOs and the expected differences in how each RTO/ISO's system needs will change over time… At this time, we do not propose a generic solution to address changing system needs across the RTOs/ISOs because of the diversity of those needs and the lack of a compelling record to support any one-size-fits-all solution for meeting those needs.") (internal citations omitted).

[158] *See* 18 C.F.R. § 385.2201(d)(iii).

V. ADDITIONAL DISCUSSION

13. Are the RTO/ISO markets compensating dispatchable resources appropriately in all markets? Are pricing policies causing premature retirements of dispatchable resources that may threaten reliability (as the MISO Midwest results may indicate)?

Existing energy and ancillary service markets, when considered alongside the Forward Capacity Market, have been sufficient to maintain a reliable power system to date, and will serve as the foundation for any market reforms proposed by the ISO as necessary to satisfy the changing resource mix and customer load profile. As described above, these potential market reforms include, among other things, developing a day-ahead market for an Energy Imbalance Reserve product and for Flexible Response Services, a potential Replacement Energy Reserve, reserve zone reforms, intertemporal optimization and pricing in the real-time markets, and reforms to Resource Capacity Accreditation. Until these reforms can be undertaken, the ISO will continue to monitor potential resource retirements in the region that may impact system reliability.

As long as retirement and entry of resources are based upon expectations of competitive market outcomes, and so long as resources are properly remunerated for both the energy they provide (in the energy markets) and their reliability contributions to the system on system planning timeframes (in the capacity market), resources' exit decisions would be the result of properly-functioning market signals, and may not generally require market interventions. In instances where resources choose to retire prematurely because the price signals they face do not presently reflect a resource's contribution to changing system needs, action may be required to ensure system reliability, including potentially the planned market reforms described above.

14. Are intermittent and hybrid resources compensated appropriately to ensure reliability?

As described in greater detail above, New England has a well-established set of market rules for compensating Intermittent Power Resources consistent with the services and capabilities they provide in the energy and ancillary service markets. These rules, while adequate for the current resource mix, will benefit from the planned market reforms described in the body of this report as the resource mix and system load profile continue to evolve, including the Resource Capacity Accreditation framework and day-ahead ancillary service reforms. The ISO and New England stakeholders are also working to ensure that hybrid resources are appropriately compensated, having recently revised energy storage participation rules to allow for participation of facilities that may be co-located with solar facilities and incapable of consuming electricity from the grid.[159] The ISO is committed to continued proactive efforts to identify and reduce barriers to participation for all resources, including Intermittent Power Resources, as the resource mix continues to evolve.

15. *Is it appropriate to continue to use LMP in energy and capacity markets? Does the continued use of LMP threaten reliability as the generation mix changes? Does the use of LMP ensure that consumers get the benefit of low clearing prices? Is there a better pricing model than LMP in RTO/ISO markets to achieve reliability and fairness to consumers?*

Locational Marginal Prices are prices designed to reflect the cost of serving the next increment of load at a given location on the system, and include the cost of energy, transmission losses, and network congestion.[160] Day-Ahead Locational Marginal Prices for energy are set on an hourly basis and calculated based on the unit commitment and economic dispatch, derived

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[159] *ISO New England Inc. & NEPOOL Participants Comm*, Continuous Storage Facility Model Tariff Revisions, Docket No. ER22-2546 (filed July 29, 2022); *see also ISO New England Inc. & NEPOOL Participants Comm*, Letter Order Accepting Tariff Revisions Related to Continuous Storage Facility Model, Docket No. ER22-2546 (September 23, 2022).

[160] *See* *Remedying Undue Discrimination through Open Access Transmission Serv. & Standard Elec. Mkt. Design*, 100 FERC ¶ 61,138 at P 204 (2002) ("Marginal pricing is the idea that the market price should be the cost of bringing the last unit to market (the one that balances supply and demand). LMP in electricity recognizes that the marginal price may differ at different locations and times. Differences result from transmission congestion which limits the transfer of electricity between the different locations. The marginal price of energy at a particular location and time -- that is, the energy LMP -- is the additional cost of procuring the last unit of energy supply that buyers and sellers at that location willingly agree on to meet the demand for energy.") (footnotes omitted).

from the prices of energy offers and bids.[161] Real-Time Locational Marginal Prices for energy are calculated on a real-time basis every five minutes.[162]

Locational marginal pricing has been a cornerstone of wholesale electricity markets in New England since the Commission's acceptance of the Standard Market Design proposal nearly two decades ago.[163] Similarly, zonal pricing based on the marginal cost of serving load has been integral to markets for capacity and reserves since the early days of electricity market restructuring. The advantage of marginal cost pricing over average cost pricing is that marginal cost constructs send both short and long-run price signals that encourage efficiency and congestion reduction in a manner that average pricing, or other pricing schemes, cannot.

Although preliminary analysis conducted as part of the ISO's long-term planning studies indicates that the changing resource mix and system load profile will lead to LMPs that are negative during an increasingly large portion of hours,[164] those price signals will reflect the most reasonably practicable method of efficiently pricing the cost to serve load during a given interval at a given location. The potential for growth in the number of hours with negative Locational Marginal Prices demonstrates the continued importance of dispatchable balancing resources that are available to serve load when needed, but are also flexible enough not to serve load responsive to negative pricing. Consistent with the ISO's mandate to facilitate economically efficient markets for energy, capacity, and ancillary services, Locational Marginal Pricing will likely continue to be the best pricing method for ensuring both reliability and efficiency of the

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[161] Tariff Section III.2.2.

[162] *Id*.

[163] *ISO New England Inc. and New England Power Pool*, 100 FERC ¶ 61,287 (2002).

[164] ISO New England Inc., 2021 Economic Study: Future Grid Reliability Study Phase 1, at ES-7 (July 29, 2022) (stating that three of the four pathways evaluated in the study would lead to negative LMPs during between 28% and 33% of hours), *available at* https://www.iso-ne.com/static-assets/documents/2022/07/2021_economic_study_future_grid_reliability_study_phase_1_report.pdf.

wholesale markets and power system, as the ISO's Tariff requires; and, by using society's energy resources in the most reliable and efficient way, maximize the system's long-term benefit to New England's economy and its electricity consumers.

16. Are capacity markets appropriate to use for resource adequacy? If not, is there a better alternative to capacity markets? Should capacity markets be purely residual or mandatory?

Like Locational Marginal Pricing, the Forward Capacity Market has been a cornerstone of the region's wholesale electricity markets for nearly two decades. It serves an important objective in New England, which is to cost-effectively meet the region's resource adequacy objective by ensuring that there are sufficient resources to satisfy the mandatory "one day in ten years" loss-of-load expectation planning standard ("1-in-10 standard"). To do this, the capacity markets provide sufficient compensation, in excess of energy and ancillary services market revenue – the "missing money" – to procure supply to meet this planning standard.

While the ISO takes no position on the necessity of capacity markets across RTOs, we do believe the Forward Capacity Market will continue to be a key component of New England's wholesale electricity markets for the foreseeable future.[165] Although some stakeholders may suggest markets for energy and ancillary services could host market signals sufficient to eliminate the need for capacity markets, this does not appear to be a viable path for New England for the foreseeable future. To achieve resource investment levels consistent with the 1-in-10 standard that FCM currently meets, the energy and ancillary services markets in New England would have to be designed based on a VOLL of approximately $116,000/MWh – or approximately 13 times higher than the $9,000/MWh energy price posted in ERCOT during

[165] ISO New England Inc., Pre-Conference Statement, *Modernizing Electricity Market Design: Energy and Ancillary Services in the Evolving Electricity Sector*, Docket No. AD21-10-000, at 2 (March 19, 2021).

Winter Storm Uri.[166] Based on these figures, and its successful role in signaling resource entry, retention, and exit for nearly two decades, the ISO believes a capacity market will continue to be a cornerstone of resource adequacy in New England for the foreseeable future.

17. How will compliance with Order No. 2222 mandating the participation and compensation of aggregated distributed energy resources (DERs) in RTO/ISO markets affect the answers to questions 1-4 above?

While ISO's proposal for compliance with Order No. 2222 remains pending, the ISO views the compliance filing's proposed rules as key next steps in a continued discussion related to wholesale market compensation structures.[167] To the extent Order No. 2222 and related compliance filings may encourage wholesale market participation by resources in greater numbers but smaller sizes, the ISO will continue to evaluate how the impacts of those resources may be integrated into existing markets or accommodated by future market and operational enhancements. However, the ISO does not view their participation in wholesale markets as fundamentally different from that of existing resources, and therefore does not believe such participation would materially impact our responses to the questions directly above.

VI. CONCLUSION

As the Commission has recognized, there is no one-size-fits-all solution to modernizing energy and ancillary service markets to meet changing system needs.[168] The ISO is actively

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[166] This figure is the MRI Scaling Factor for the fifteenth Forward Capacity Auction. The Scaling Factor is the expected long-run marginal cost to acquire sufficient resources to achieve a loss of load equal to 0.1 in New England over time. The value is updated and published annually as part of the FCM Demand Curve development process and is $116,178/MWh for the most recent completed auction. *See* details at https://www.iso-ne.com/static-assets/documents/2022/08/a3_fca_17_demand_curves.xlsx, 'Readme' tab, Scaling Factor values.

[167] ISO New England Inc., Order No. 2222 Compliance Proposal, at 36–38 (February 2, 2022), *available at* https://www.iso-ne.com/static-assets/documents/2022/02/order_no_2222_filing.pdf.

[168] Order Directing Reports at PP. 4–5. ("Panelist discussions at the E&AS conferences and post-conference comments did not identify a clear generic or "one-size-fits-all" solution to modernizing E&AS markets to meet changing system needs. Rather, panelists stressed that system needs will differ significantly across RTOs/ISOs, in large part due to differences in resource mixes across RTOs/ISOs and the expected differences in how each

engaged in long-term planning processes with our state partners, NESCOE, and the NEPOOL stakeholders to ensure the region is prepared for future changes to the resource mix and load profile. As system needs and resource performance capabilities continue to evolve, it will be critically important to balance cost and complexity of any contemplated market reforms or operational enhancements with the economic efficiency and reliability benefits of additional capabilities and services. These observations help to highlight the state of information in this rapidly-evolving system, and as technology continues to change and resources that are not yet operational begin to participate in the markets, the ISO will continue to refine its understanding of future system needs through sound analysis and data-driven processes. We look forward to continued efforts by the Commission to remain responsive to the evolving resource mix and load profiles of individual RTO/ISO regions, and any related future market reforms that the evolving energy system may motivate.

Respectfully submitted,

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RTO/ISO's system needs will change over time… At this time, we do not propose a generic solution to address changing system needs across the RTOs/ISOs because of the diversity of those needs and the lack of a compelling record to support any one-size-fits-all solution for meeting those needs.") (internal citations omitted).

CERTIFICATE OF SERVICE

I hereby certify that I have this day served the foregoing document upon each person designated on the official service list compiled by the Secretary in this proceeding.

Dated at Holyoke, Massachusetts this 18th day of October 2022.

/s/ Julie Horgan
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