ConnectedSolutions

Energy Storage for Winter Grid Reliability

HOW BATTERIES BECAME THE LOW-COST SOLUTION FOR POWER ASSURANCE IN MASSACHUSETTS

Prepared by Applied Economics Clinic for Clean Energy Group

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Applied Economics Clinic
Economic and Policy Analysis of Energy, Environment and Equity

CleanEnergyGroup

ABOUT THIS REPORT

This report, prepared by the Applied Economics Clinic (AEC) on behalf of Clean Energy Group (CEG), presents an analysis of the value of winter grid capacity services, called "winter reliability," in New England; assesses the cost of various energy resources available to supply this service in Massachusetts; and makes recommendations regarding energy storage incentive and compensation rates to meet the Commonwealth's future winter reliability needs.

This report is part of CEG's ongoing series on the ConnectedSolutions battery funding model. CEG previously advocated for the addition of energy storage as a demand reducing measure within the Massachusetts energy efficiency program. In the course of this work, CEG contracted with AEC to produce a cost-benefit analysis for behind-the-meter energy storage in Massachusetts, and also for analysis valuing seven non-energy benefits of energy storage. This prior work was published in CEG's April 2019 report, *Energy Storage: The New Efficiency—How States Can Use Efficiency Funds to Support Battery Storage and Flatten Costly Demand Peaks*. CEG followed this with two additional reports published in February 2021: *ConnectedSolutions: A New State Funding Mechanism to Make Battery Storage Accessible to All*, and *ConnectedSolutions: The New Economics of Solar+Storage for Affordable Housing in Massachusetts*. In September 2021, CEG again partnered with AEC to publish *ConnectedSolutions: A Program Assessment for Massachusetts*. This current report represents a furtherance of this earlier work. Learn more about CEG's work on energy storage policy at http://www.cleanegroup.org.

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ABOUT THE APPLIED ECONOMICS CLINIC

Based in Arlington, Massachusetts, the Applied Economics Clinic (AEC) is a mission-based nonprofit consulting group that offers expert services in the areas of energy, environment, consumer protection, and equity from seasoned professionals while providing on-the-job training to the next generation of technical experts. AEC's nonprofit status allows us to provide lower-cost services than most consultancies and when we receive foundation grants, AEC also offers services on a pro bono basis. AEC's clients are primarily public interest organizations—nonprofits, government agencies, and green business associations—who work on issues related to AEC's areas of expertise. Our work products include expert testimony, analysis, modeling, policy briefs, and reports, on topics including energy and emissions forecasting, economic assessment of proposed infrastructure plans, and research on cutting-edge, flexible energy system resources. AEC works proactively to support and promote diversity in our areas of work by providing applied, on-the-job learning experiences to graduate students—and occasionally highly qualified undergraduates—in related fields such as economics, environmental engineering, and political science. Find out more at www.aeclinic.org.

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Executive Summary

Winter electric peaking capacity (called "winter reliability" in New England) provides an important value to the electric grid by helping to avoid winter blackouts. As heating and transportation are increasingly electrified to meet climate goals, winter peak energy needs will grow; and as fossil-fueled generators are phased out due to emissions caps, new, clean sources of winter peaking capacity will need to be found.

Although winter peaking capacity has traditionally been provided by gas and oil peaking generators (peaker plants), it can also be provided by cleaner, "behind-the-meter" customer resources such as battery storage. Currently, this service is undervalued in the Massachusetts programs that provide battery customers with performance payments to supply power back to the grid at times of high demand. These customer performance payments should be adjusted to reflect the true value of winter electric peaking capacity in the region.

This report examines the current pricing and valuation of winter peaking resources in Massachusetts. Findings include the following:

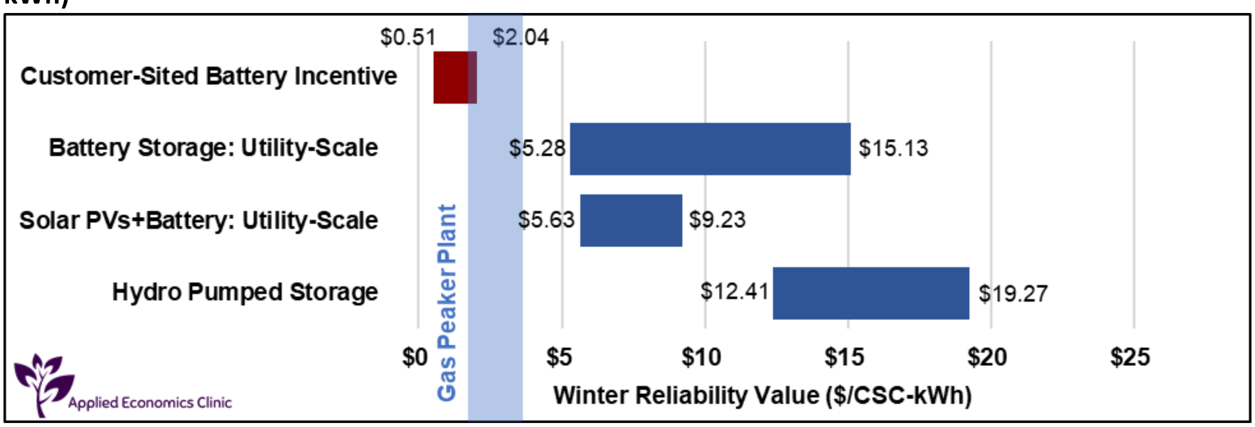
1. Among the supply-side and demand-side measures reviewed in this report, customer-sited battery storage is by far the lowest priced new winter peaking resource now available to utilities, meaning that battery-owning (or leasing) customers who contract with utilities to supply capacity to the grid are being under-compensated for the services they provide.
2. As the current portfolio of gas peaking plants is retired, more customer-sited batteries—the cheapest new winter peaking resource available—will be needed to replace them. The pace of this transition will accelerate with increasing electrification in the transportation and heating sectors, which will add to the need for winter peaking resources, and with the implementation of air emissions caps, which will hasten the retirement of existing greenhouse gas emitting peakers and prohibit the building of new fossil-fuel peakers to replace them.
3. To convince more customers to install solar PV and battery storage and provide peaking resources to the grid, higher performance payment rates will be required, and program budgets will need to be increased.
4. Customer performance payments are tied to the value of the grid services those customers can provide. At present, the value of winter peaking capacity services from distributed (customer-sited) resources is assumed to be $0 in battery program cost-benefit analyses (to be clear, winter peaking programs do have incentives in Massachusetts, however, the value of these performance payments is set using a method that assumes no monetary benefit from the provision of winter peak itself). A more realistic (and positive) value for winter reliability services should be calculated, and that value should be incorporated into battery program economics and reflected in higher customer performance payments.
5. These new, higher customer performance payments should be implemented now, to allow for a smooth transition away from centralized fossil-fuel peaking resources and toward customer-sited, non-emitting resources.

Indexing customer performance payments to gas peaker costs sets customer incentives artificially low

Incentivizing electric customers to provide energy supply from customer-sited batteries or to curtail their electric usage during peak demand periods is by far the cheapest way for electricity suppliers to secure new zero-carbon resources for winter peak electric demand. All current customer performance payments for battery and demand response in Massachusetts are equal to or less than the cost for a newly built gas peaker to provide winter reliability.

In this report, we introduce a winter reliability metric defined as the assurance of adequate electric capacity during periods of critical need, called—following ISO-New England's convention—capacity scarcity condition (CSC) events. AEC calculated a "winter reliability value" measured as the net dollar value to supply any given peak supply technology (i.e., gas peaker or large-scale battery storage) on a per kilowatt-hour (kWh) basis during a CSC period. Using this metric, current battery and demand response customer performance payments range from $0.51 to $2.78 per CSC-kWh (as compared to the new gas peaker range of $1.79 to $3.94 per CSC-kWh) (see Figure ES-1). Among new "utility-scale" (meaning large-scale and not owned by customers) peak supply technologies, gas peakers are currently the least expensive option: Electric distributors are designing their customer performance payments to meet, but not exceed, this cheapest large-scale supply alternative. As gas peakers retire, and emissions regulations prevent replacing them with new gas peakers, customer-sited battery storage will become the cheapest option for new winter reliability services.

Figure ES-1. Comparison of customer performance payments (red), new non-combustion supply technology costs (dark blue), and new gas peaker costs (light blue) for serving winter peak ($/CSC-kWh)



Note: The vertical light blue area shows the range of costs for a new gas peaker: $1.79 to $3.94/CSC-kWh.

If gas peakers were not an option for supplying winter peak demand, electric distributors would be willing to pay customers higher battery program performance payments. As Massachusetts greenhouse gas emissions laws gradually eliminate gas peakers as an option for electric distributors, the next cheapest large-scale peaking resource will be large ("utility-scale") batteries, with a winter reliability cost of $5.28 to $15.13 per CSC-kWh. When gas peakers are no longer available, electric distributors should be willing to pay at least $5.28 per CSC-kWh in customer battery performance payments, and perhaps more, compared to the current $0.51 to $2.78 per CSC-kWh, in order to enroll more customers to meet the Common-wealth's winter peaking needs.

Some number of additional battery customers can likely be enrolled at current performance payment levels, but higher performance payment rates are probably needed to bring enrollment to scale to meet Massachusetts' ambitious Clean Peak Standard. The question of how much additional enrollment is possible at existing payment levels is a topic warranting further research. Although research has shown that early adopters of customer-sited battery technology place a high value on non-monetizable benefits of energy storage, such as energy reliability during emergencies and/or greenhouse gas emissions reductions, such early adopters are in the minority. While these households and businesses may be willing to invest in battery storage or related demand response mechanisms even though they receive incommensurate performance payments to supply electric capacity at times of peak demand, the number of customers willing to make such investments is limited. Higher performance payments for these programs will increase the number of participants by bringing in customers with weaker non-monetary motivations. As Massachusetts' emissions limits become more stringent each year, electric distributors have an economic impetus to raise performance payments and increase participation in their customer supply programs.

Increasing the supply of customer-owned capacity resources should anticipate, not follow, capacity scarcity

When, as a consequence of emissions limits, gas peakers are no longer an option for meeting winter peak demand, electric distributors will find it economic to raise battery incentive prices. Higher performance payments will then increase participation in battery programs and the amount of energy provided by customers' batteries at times of peak winter demand.

However, waiting until gas peakers are phased out to raise customer battery performance payments could create a gap in winter capacity supply. Furthermore, allowing utilities to raise performance payment rates for batteries only when forced to do so means that current battery customers will continue to be under-compensated for services they are providing to the grid. Instead, public clean energy programs that provide performance payments in exchange for customer-owned or -leased battery services should increase customer compensation rates to be at least commensurate with the rates paid to large-scale energy storage suppliers of the same service, and they should do so immediately. This will increase program participation and customer supplied capacity resources. To achieve this, larger program budgets will be necessary.

Failure to anticipate and plan for replacement capacity will result in high costs for current and future energy customers and a slower transition to a decarbonized electric sector.

A positive value for winter reliability is critical

By allowing the value of winter reliability services to default to $0 in cost-benefit tests, program administrators in Massachusetts are failing to properly assess the cost-effectiveness of battery storage. Utilities and state energy agencies need to correctly assess the value that winter peak resources bring to the region, and accurately allocate funding towards customer performance payments for batteries on this basis. Future dollar values for these program performance payments should increase based on anticipated gas generator retirements and growing customer needs for winter peak supply, driven by the increasing electrification of heating and transportation. In order to achieve this, a realistic value for winter reliability services must be established, and that value must be used (in addition to summer capacity values) in program cost-benefit tests.

Policy recommendations

Based on the findings in this report, we make the following policy recommendations to Massachusetts energy policymakers, regulators, and program administrators:

1. Customer performance payment rates for battery services should be increased at least 33 percent from their current level. To accommodate this, and to allow for program enrollment growth, program budgets should also increase.
2. The value of winter reliability services is greater than zero. The true value of these services should be calculated and used in cost-benefit analyses conducted by program administrators, and these values should be reflected in customer performance payment rates.
3. The time to make positive changes to battery program performance payments and budgets is now. Failure to anticipate the growing need for these customer services will result in higher costs for all ratepayers and could hinder achievement of the Commonwealth's clean energy and climate goals.

Further research needs

Going forward, important areas for related research include the following:

- A specific valuation of winter reliability services, as separate from summer capacity
- Appropriate customer incentive levels as a consequence of this value
- The most cost-effective scale of clean energy and energy storage incentive program budgets, taking into consideration upcoming retirements of emitting resources
- What other programs and regulations may require adjustment due to updated winter reliability values and customer performance payments

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I. Introduction

Massachusetts electric distributors provide their customers with performance payments to invest in battery storage and other customer-supplied electric capacity resources. These behind-the-meter resources provide value to the grid, and the customer performance payments are calculated based in part on that value. However, in their consideration of what performance payments are appropriate, electric companies do not currently take into account the value of winter capacity services these customers provide to the grid ("winter reliability").

Winter capacity services are necessary to avoid blackouts during the coldest months when, according to ISO-New England, gas supply for power generation is more constrained due to competing needs for heating.[1] The value of winter electric capacity is treated by electric distributors as distinct from that same value in summer, and it has been dubbed "winter reliability" to distinguish it from "summer capacity." **When calculating customer performance payments, summer capacity services are valued, but winter reliability services are not.**

Supplying electricity to meet customer demand during times of peak winter energy usage is valuable; however, the administrators of Massachusetts' efficiency and "demand-side management" incentive programs are incorrectly valuing it at $0 when calculating performance payments. The best evidence of its value is the fact that electric distributors, the Commonwealth of Massachusetts, and the electric system operator are all willing to pay for it. For example, during the 2019/2020 winter season, utilities paid between $0.51 to $2.78 per peak kilowatt-hour for winter peaking capacity from a variety of sources, including customer-owned battery storage.

Meeting winter peak needs is not guaranteed by having enough capacity resources to meet summer peak; resources can, and do, have different availability and different prices in summer versus winter. Furthermore, as New England states electrify heating and transportation to meet their climate goals, peak winter energy needs will grow, and peak electric supply (winter reliability) will need to grow too. At the same time, emissions caps will force the retirement of fossil-fuel peaker plants, meaning that as the need for winter reliability increases, the available resources to supply it will decrease. New sources of winter reliability capacity will have to be found.

Today, offering performance payments to electric customers in exchange for peak supply from customer-sited batteries or "demand response" programs (in which customers curtail their electric usage during peak demand hours) is by far the cheapest way for electric distributors to secure new zero-carbon resources for winter peak electric demand. These programs cost less than $3 per kilowatt-hour (kWh) needed in a condition of energy scarcity (called CSC-kWh in this report). That incentive rate was created to reflect the current cost of services from existing gas peakers, the cheapest current source of winter reliability services. By comparison, based on the analysis presented in this report, the next cheapest source of new zero-carbon winter peaking capacity is large-scale batteries, which are currently priced at $5.28 to $15.13 per CSC-kWh.

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[1] Hibbard, P. and Craig P. A. 2015. "Power System Reliability in New England." *Analysis Group, Inc.* Available at: https://www.scribd.com/document/290193152/AG-Maura-Healey-s-Energy-Study

As peak demand grows, old oil or gas "peaker" plants (designed to run for short bursts of time) will retire, and legal obstacles to building new gas peakers will mount. Greenhouse gas emission reduction policies in Massachusetts (and throughout New England) work by internalizing the previously externalized costs of fossil fuel-based generation, such as air emissions. This makes gas and other fossil fuels more expensive, and their usage is anticipated to decline steeply over the next few decades.[2]

Some electric customers with batteries are willing to provide peak electric supply in exchange for small performance payments because they have other reasons to invest in battery storage, such as strong environmental convictions and concerns regarding electric reliability and storm resiliency; but the number of customers who will invest in battery storage for these non-economic reasons is limited. To secure the amount of winter peak supply needed in the near future, electric distributors will need to significantly increase the number of battery program participants, and that will require higher performance payment rates.

Assigning winter reliability a positive value in decision-making regarding the size and number of customer performance payments will support higher incentives and increase the amount of customer-supplied electric capacity procured. It is important that these performance payments reflect the real value of these demand-side services.

Arguably, the dollar value of winter reliability is the amount that electric distributors are willing to pay to secure it. Today, distributors can buy inexpensive winter peak supply from existing gas peaker plants, and they are willing to pay that same price (or lower) as a performance payment to customers who can provide the same service: around $3 per CSC-kWh. However, the current prices are low in part because they do not reflect the cost of externalities associated with fossil-fuel peaker plants. These externalities include greenhouse gas emissions and air pollutants that contribute to negative health effects, especially in the densely populated urban environments where gas peakers are frequently sited. When the cost of these externalities begins to be internalized (that is, included in market prices), the cost of winter reliability services from existing gas peaker plants increases substantially.

Massachusetts[3] and other states are increasingly restricting the use of fossil-fuel peaker plants in order to reduce these harmful externalities. Continuing to set customer battery performance payment rates based on the cost of services from fossil-fueled peakers, which are being eliminated from the Commonwealth's generation portfolio due to their pollution and greenhouse gas emissions, would mean holding customer battery performance payments to an artificially low level.

[2] The Global Warming Solutions Act, adopted in 2008, sets statewide greenhouse gas emissions targets that grow progressively more restrictive. In addition, the Commonwealth continues to adopt new policies and programs accelerating these changes. For example, Governor Baker recently signed into law *An Act Creating a Next Generation Roadmap for Massachusetts Climate Policy* requiring more renewables development, better energy efficiency standards, earlier greenhouse gas emission reduction targets, and protections for economically vulnerable communities during the clean energy transition. Source: The Commonwealth of Massachusetts. 2021. "An Act Creating a Next-Generation Roadmap for Massachusetts Climate Policy." *192nd General Court.* Available at: https://malegislature.gov/bills/192/S9

[3] Massachusetts Department of Environmental Protection. 2020. "310 CMR 7.74: Reducing CO2 Emissions from Electricity Generating Units." *Massachusetts Register.* Available at: https://www.mass.gov/regulations/310-CMR-700-air-pollution-control; The Commonwealth of Massachusetts. 2008. "An Act Establishing the Global Warming Solutions Act." *192nd General Court.* Available at: https://malegislature.gov/Laws/SessionLaws/Acts/2008/Chapter298

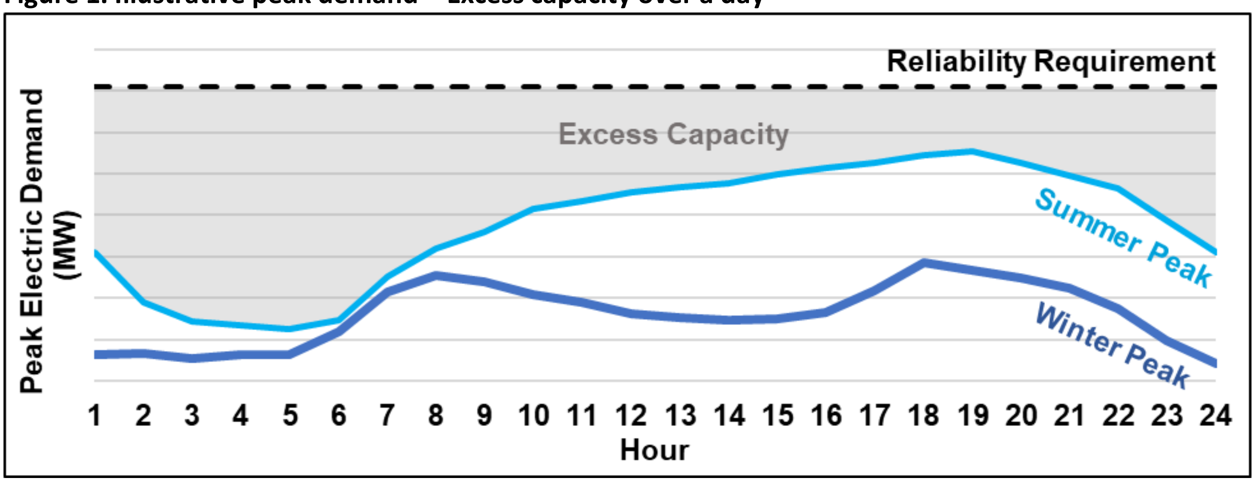
Because gas peakers are now an endangered species in Massachusetts, electric distributors' cheapest source of new non-customer-sited, emission-free winter peak resources is large-scale battery storage and solar PV plus battery storage installations. As capacity from gas peakers becomes unavailable, electric distributors should be willing to pay customers who can provide behind-the-meter, emission-free winter peak supply the same rate as they would pay large-scale energy storage suppliers: $5 to $15 per CSC-kWh. This means that ***customer battery performance payments should increase a minimum of 33 percent over their current level.***

In this report, we look at the value of winter reliability services and the opportunity to provide these services economically in New England using distributed battery storage. Section II provides background on electric generating capacity in the summer and winter, New England's Forward Capacity Market (FCM), and the concept of winter reliability. Section III offers a brief discussion of the importance of winter reliability for the region. Section IV provides a detailed look at the value of winter reliability in New England and identifies peak management measures (customer incentive programs and peak supply technologies) available to the region. Section V offers policy recommendations based on this analysis.

II. The Avoided Cost of Electric Capacity: Summer and Winter

Electricity costs include not only the cost of fuel and other expenses needed to produce any given megawatt-hour (MWh) but also the cost of having excess electric generating capacity at the ready to meet unexpected spikes in demand or decreases in generating capacity. Because electric usage varies greatly over the course of a day (see Figure 1) and a year (see Figure 2), a much larger amount of electric generating capacity must be available to run than is actually used in most hours of the year. This excess capacity is the most expensive power in the market.[4]

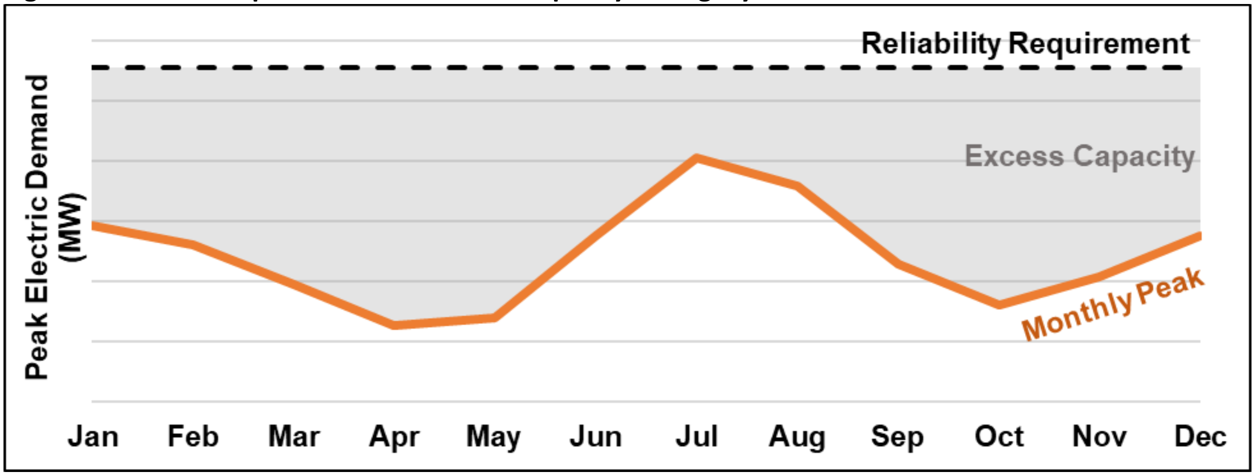
Figure 1. Illustrative peak demand – Excess capacity over a day



Source: AEC illustration.

[4] "Over the last three years from 2013 – 2015 on average, the top 1% most expensive hours accounted for 8% ($680 million) of Massachusetts ratepayers' annual spend on electricity. The top 10% of hours during these years, on average, accounted for 40% of annual electricity spend, over $3 billion." (Source: Massachusetts Department of Energy Resources. July 2017. State of Charge: Massachusetts Energy Storage Initiative Study. pp. i-ii. Available at: https://www.mass.gov/files/2017-07/state-of-charge-report.pdf)

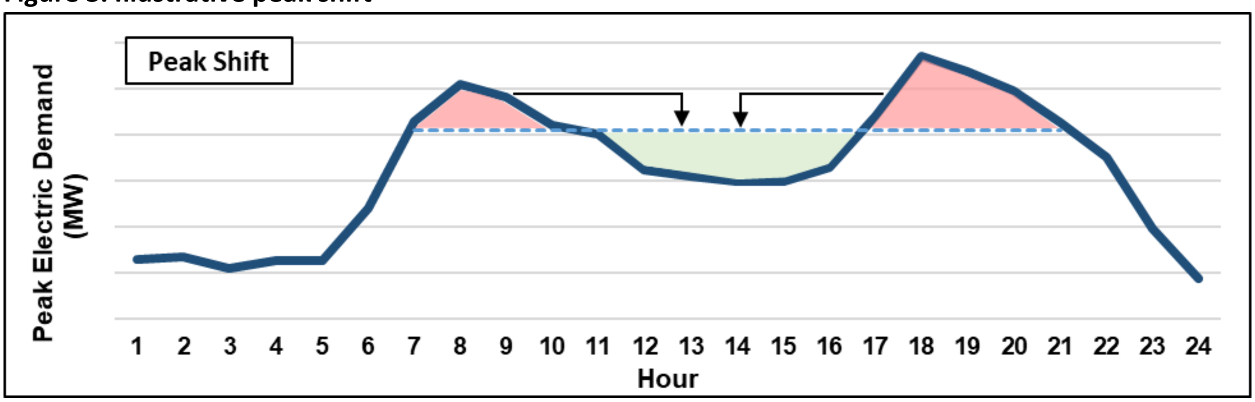
Figure 2. Illustrative peak demand - Excess capacity during a year



Source: AEC illustration.

For this reason, technologies—like battery storage—that can shift effective electric demand away from hours of peak use have the potential to lower customer electric rates (see Figure 3).[5] If peak needs were lower, or shifted to off-peak times, variation in demand would be reduced, and less total generating capacity would be needed on the system. Fewer new "peakers plants" would be built and a smaller fleet of power plants would be less costly to support.

Figure 3. Illustrative peak shift



Note: Peak-shifting resources such as battery storage can absorb electricity during low-demand hours and release it to the grid or to support customer loads during peak demand hours. This effectively shifts some of the load from peak hours (red) to off-peak hours (green) and thereby reduces the need to maintain a large fleet of expensive and polluting fossil-fuel peaker plants. Source: AEC illustration.

[5] This shift is sometimes called Demand Reduction Induced Price Effects (DRIPE). See https://www7.eere.energy.gov/seeaction/publication/state-approaches-demand-reduction-induced-price-effects-examining-how-energy-efficiency.

Batteries can achieve this effect in two ways: (1) they can absorb excess electricity generated at off-peak times and inject that stored energy onto the grid during demand peaks; or (2) they can use that stored power behind the meter to supply electricity to customer loads during demand peaks, thus lowering peak demand from the customer side. Both of these battery operation mechanisms are currently in use in Massachusetts.[6]

In New England, owners of generation facilities are compensated in the Forward Capacity Market (FCM) for their assurance that they will provide electricity at the region's peak hours of need: Generators bid their available capacity into an auction in which the least expensive resources (in terms of the dollar value bid in for their promise to provide capacity) are selected first, and so on up to the most expensive generator needed to reliably supply electricity during New England's peak summer hour. All generators that are selected receive that highest dollar per megawatt (MW) price multiplied by the number of MWs they bid (see Table 1). Generators with bids higher than the top bid selected receive nothing.

Table 1. Results of annual forward capacity auctions (FCA) by capacity commitment period (CCP)

Auction Commitment Period	Total Capacity Acquired (MW)	New Demand Resources (MW)	New Generation (MW)	Clearing Price ($/kW-month)
FCA #8 in 2014 for CCP 2017/2018	33,712	394	30	$15.00/new & $7.025/existing
FCA #9 in 2015 for CCP 2018/2019	34,695	367	1,060	System-wide: 9.55 SEMA/RI: $17.73/new & $11.08/existing
FCA #10 in 2016 for CCP 2019/2020	35,567	371	1,459	$7.03
FCA #11 in 2017 for CCP 2020/2021	35,835	640	264	$5.30
FCA #12 in 2018 for CCP 2021/2022	34,828	514	174	$4.63
FCA #13 in 2019 for CCP 2022/2023	34,839	654	837	$3.80
FCA #14 in 2020 for CCP 2023/2024	33,956	323	335	$2.00

Source: ISO-New England. n.d. "Markets." ISO-NE. Avalable at: https://www.iso-ne.com/about/key-stats/markets#fcaresults

[6] Option one (the use of batteries to inject power onto the grid during times of peak demand) is especially important for residential and smaller commercial customers who would not otherwise be able to economically install battery storage because their home or facility peak demand (called "load") is small, and therefore the potential earnings for reducing their peak usage are limited.

New England's capacity reliability requirement is set based on the generation needed during the region's summer peak (the highest electric usage of the year) plus a 16.1 percent reserve margin—a contingency against generator outages.[7] The capacity market clearing price is used in calculating the value of energy efficiency and other demand-side measures; capacity market clearing prices represent the value of avoided generation capacity that need not be built because of new efficiency investments.

In Massachusetts, recent expansion of energy efficiency valuation into active demand reduction measures included the potential for avoided generation capacity costs in both summer and winter. But because the capacity market price is set based on the summer peak only, batteries and other demand-side measures are currently assigned the FCM price for avoided summer capacity and a value of $0 for avoided winter capacity. This impacts the cost-effectiveness of these resources in cost-benefit analyses and may also impact how performance payment rates are set for these resources.[8]

Because reduced demand for peak generation capacity in winter does not avoid New England capacity market purchases (which are based on summer peak), serving the winter peak is not assigned the FCM value, and it is called winter "reliability" instead of winter "capacity" in reference to this difference. Nonetheless, reducing the need for winter peak capacity (in other words, increasing winter reliability) holds a substantial value for Massachusetts as the Commonwealth works to balance coincident demands between gas used for heating and for electric generation.[9] Understanding the value of this improved winter reliability is important for accurately valuing peak reducing measures. This in turn should inform cost-benefit analyses and performance payment rates for these measures.

In their 2019-2021 three-year energy efficiency plan,[10] Massachusetts' electric energy efficiency program administrators acknowledge the impact of energy storage, an active demand reduction measure, on winter reliability:

> *The innovations in this Plan include new active demand reduction efforts that will have an impact on summer peak demand and winter reliability, while strongly supporting the Commonwealth's greenhouse gas reduction goals.[11]*

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[7] The 16.1 percent reserve margin is based on a proposed net installed capacity requirement of 33,770 MW. Kotha, M. August 30, 2018. *Proposed Installed Capacity Requirement (ICR) Values for the 2022-2023 Forward Capacity Auction (FCA 13)* [PowerPoint Slides]. ISO-New England. Available at: https://www.iso-ne.com/static-assets/documents/2018/08/a3_pspc_prpsd_icr_values_08302018.pdf p.7

[8] Massachusetts Program Administrators.2018. "BCR Model" spreadsheets. "Massachusetts Joint Statewide Electric and Gas Three-Year Energy Efficiency Plan: 2019-2021". http://ma-eeac.org/wordpress/wp-content/uploads/2019-2021-Three-Year-Energy-Efficiency-Plan-April-2018.pdf. For more discussion see: Stanton, E.A. April 2019. *Updated Massachusetts Battery Storage Measures: Benefits and Costs*. Applied Economics Clinic White Paper. AEC-2019-04-WP-01. https://aeclinic.org/publicationpages/2019/3/15/updated-massachusetts-battery-storage-measures-benefits-and-costs

[9] Massachusetts Department of Public Utilities. Docket Nos. 18-116, 18-117, 18-118, 18-119. *Three Year Energy Efficiency Plan for 2019 through 2021*. October 31, 2018. BCR Spreadsheet submitted with "Massachusetts Joint Statewide Electric and Gas Three Year Energy Efficiency Plan: 2019-2021". Available at: http://ma-eeac.org/wordpress/wp-content/uploads/Exh.-1- Final-Plan-10-31-18-With-Appendices-no-bulk.pdf

[10] MassDPU. Docket Nos. 18-116, 18-117, 18-118, 18-119.

[11] MassDPU. Docket Nos. 18-116, 18-117, 18-118, 18-119. p.20-30

But these same program administrators nonetheless value the winter reliability value of energy storage at $0 per MW in the cost-benefit analyses used in setting program offerings.[12]

The Commonwealth's approved 2019-2021 energy efficiency plan explained that a winter reliability benefit was under development:

> *The Program Administrators have agreed with DOER and the Attorney General to conduct a study to be commenced in Q1 of 2019 to quantify any benefits associated with winter peak capacity reduction. The PAs will issue an RFP and conduct this study in collaboration with the DOER, the Attorney General and the Council consultants. Study results will be aligned with and compatible with the 2018 AESC. If new benefits are identified as a result of this study, the Program Administrators will apply those benefits to reported values.*[13]

The program administrators' initial report,[14] released in May 2020, takes a different approach than the analysis presented in this publication by examining several potential sources of avoided costs provided by capacity resources at winter peak along with methods for estimating the value of these methods using modeling data. (In contrast, our approach infers the value of capacity resources at winter peak from the performance payments already offered in New England.) The program administrators' study does not present a proposed value for a winter reliability benefit.

Underestimating the value of winter reliability has the effect of lowering New England's overall "avoided cost of supply" estimates that place a value on resources that avoid a need for generating capacity: energy efficiency, demand response, and battery storage. The lower the value assigned to this estimated benefit (the avoided cost of supply), the lower the payments electric suppliers are required to provide to customers who provide energy efficiency, demand response, and battery storage services. (In "all-cost-effective" states like Massachusetts, electric distributers are required to provide customers with all efficiency and other demand-side measures that cost less than the avoided cost of electric supply. The higher the avoided cost, the more demand-side measures qualify as cost effective and must be made available to customers.)

As discussed in the next section, Massachusetts and other states in the region must balance coincident demands for gas used for heating and for electric generation while accounting for growing winter electric demand as more Massachusetts families choose to electrify their heating with high-efficiency heat pumps. The importance of increasing winter reliability has become a prevalent talking point among New England decision-makers.

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[12] Massachusetts Department of Public Utilities. Docket Nos. 18-116, 18-117, 18-118, 18-119. *Three Year Energy Efficiency Plan for 2019 through 2021*. October 31, 2018. BCR Spreadsheet submitted with "Massachusetts Joint Statewide Electric and Gas Three Year Energy Efficiency Plan: 2019-2021". Available at: http://ma-eeac.org/wordpress/wp-content/uploads/Exh.-1- Final-Plan-10-31-18-With-Appendices-no-bulk.pdf

[13] MassDPU. Docket Nos. 18-116, 18-117, 18-118, 18-119. p.169

[14] Knight, P., M. Chang, J. Hall, P. Chernick. May 2020. *AESC Supplemental Study. Part I: Considering Winter Peak Benefits.* Synapse Energy Economics. Prepared for Massachusetts Electric Energy Efficiency Program Administrators. Available at: https://ma-eeac.org/wp-content/uploads/AESC-Supplemental-Study-Part-I-Winter-Peak.pdf

III. Winter Reliability is Valuable to New England

ISO-New England (the regional electric system operator), local electric distributors, and state agencies agree that increasing winter reliability in the region is valuable and necessary to meet peak electric demand in winter and avoid unintended economic and environmental consequences. In New England, the required electric generating capacity for a given year is determined by the expected summer peak demand. This allows ISO-New England to adequately meet peak demand in the summer but fails to account for external factors that have the potential to influence the grid's ability to meet peak electric demand in winter.

Insufficient electric supply in winter months has the potential to substantially increase electric supply costs—or result in localized blackouts, a much rarer outcome given New England's careful reliability planning.[15] As an initial response to the region's winter reliability concerns, ISO-New England implemented its Winter Reliability Program in 2013 to create an incentive for the procurement of both fuel reserves before winter begins, and demand-response resources to reduce winter peak demand.[16] According to ISO-New England, this program played a valuable role in keeping electric generators in operation throughout the coldest winter conditions:

> *To address the serious challenge these constraints create for reliable power system operation and to ensure that generators can run during times of system stress, ISO New England will again employ a Winter Reliability Program to incentivize oil-fired generators and generators that can access liquefied natural gas to procure sufficient fuel before winter begins. The program has been a key factor in our ability to keep the lights on the last two winters.*[17]

In 2018, the Winter Reliability Program was replaced by ISO-New England's more comprehensive Forward Capacity Market (FCM) Pay-for-Performance program for electric generators, which aims to increase financial incentives for reliability investments that would meet demand during periods of critical need.[18] ISO-New England uses the term "capacity scarcity condition" or "CSC" to refer to these periods of critical need and scarce supply resources.

In addition to the FCM Pay-for-Performance project, ISO-New England has other programs called "Winter Energy Security Initiatives" that provide compensation to resources providing winter energy security to the region. One of these initiatives, known as the Interim Compensation Treatment project, compensates resources that improve winter reliability, and serves as a bridge to the Energy Security Improvements project—a long-term market-based approach currently under development.[19]

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15 Note also the impact of the polar vortex on both customer demand and fuel supplies. See https://www.nrdc.org/experts/john-moore/polar-vortex-and-power-grid-what-really-happened-and-why-grid-will-remain

16 ISO Newswire. October 27, 2017. "Update on the 2017/2018 Winter Reliability Program". Available at: http://isonewswire.com/updates/2017/10/27/update-on-the-20172018-winter-reliability-program.html

17 ISO-New England. December 2015. "Press Release – Winter 2015/2016: Sufficient Power Supplies Expected to be Available. Holyoke, MA". Available at: https://www.iso-ne.com/static-assets/documents/2015/12/20151201_winter_outlook_release_final.pdf

18 https://www.iso-ne.com/participate/support/customer-readiness-outlook/fcm-pfp-project

19 ISO-New England. "Interim Compensation Treatment Key Project." Available at: https://www.iso-ne.com/committees/key-projects/interim-compensation-treatment

In 2018, New England's Governors released a joint statement on regional energy affordability addressing the benefits of conservation in winter months:

> *The New England states, working in collaboration, commit to making energy costs in the region more affordable. In the short term, the states will actively collaborate this fall to develop a mechanism for engaging residents and business in conservation efforts during cold snaps; such efforts would communicate the economic and reliability benefits of conservation during winter months. Given state jurisdiction over energy resource choices as well as environmental policies, the New England states have a crucial role in implementing regional solutions. We look forward to working with ISO New England, New England Power Pool, and other stakeholders in achieving this goal.*[20]

It is clear from the efforts described above that winter reliability—ensuring adequate generating capacity in winter months—has an important value to New England electric customers. However, estimating the dollar value of winter reliability poses some challenges, discussed in the next section.

IV. Estimating the Value of Winter Reliability in New England

Although Massachusetts energy efficiency program administrators do not currently account for the value of customer-supplied electric capacity resources that reduce the need for winter peaking capacity, ISO-New England, local electric distributors, and state agencies have made it clear that winter reliability is critical for the region to adequately meet customers' needs. Thus, the true value of winter reliability is clearly not $0—but how should we value it? Calculating a specific dollar value for winter reliability services is beyond the scope of this report, but we can provide an estimated value based on the prices paid for a range of demand-side programs and supply-side generating technologies.

In this report, winter reliability is defined as the assurance of adequate electric capacity during periods of critical need, called—following ISO-New England's convention—capacity scarcity condition (CSC) events.[21] AEC calculated a "winter reliability value" measured as the net dollar value to supply any given peak supply technology (i.e., gas peaker or large-scale battery storage) on a per kilowatt-hour (kWh) basis during a CSC period. This is a new metric introduced in this report that we denominate as $ per CSC-kWh. To isolate the cost to provide winter reliability using each peak supply technology, AEC netted out the additional revenue streams that these resources receive from energy and (summer) capacity markets (see Appendix: Methodology and Assumptions for further details).

To estimate a monetary value of winter reliability, AEC considered two kinds of peak management options: (1) customer performance payments and (2) peak supply technologies (see Table 2).

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[20] Malloy, D., Baker, C., Sununu, C., Raimondo, G., & Scott, Phil. August 2018. "Press Release – New England Governors Statement on Regional Energy Affordability. Stowe, VT". Available at: https://governor.vermont.gov/press-release/new-england-governors-statement-regional-energy-affordability

[21] We borrow this terminology from ISO-New England, which defines a "capacity scarcity condition" as an event in which the ISO is unable to meet one or more of its reserve requirements. ISO-NE. 2018. "2018 Annual Markets Report." Available at: https://www.iso-ne.com/static-assets/documents/2019/05/2018-annual-markets-report.pdf.

Customer performance payments incentivize customers to reduce demand or provide stored energy to the electric grid at times of peak demand (program examples include Electric Vehicle Load Management, Winter Interruptible Load Curtailment, Demand Response (ConnectedSolutions), Massachusetts Clean Peak Standard, ISO-New England Winter Reliability Program, and ISO-New England Pay-for-Performance).

Peak supply technologies are large-scale generation or generation plus energy storage resources used to supply peak needs (for example, gas peaker plants,[22] electric battery storage, solar photovoltaics with battery storage, and hydroelectric pumped storage).

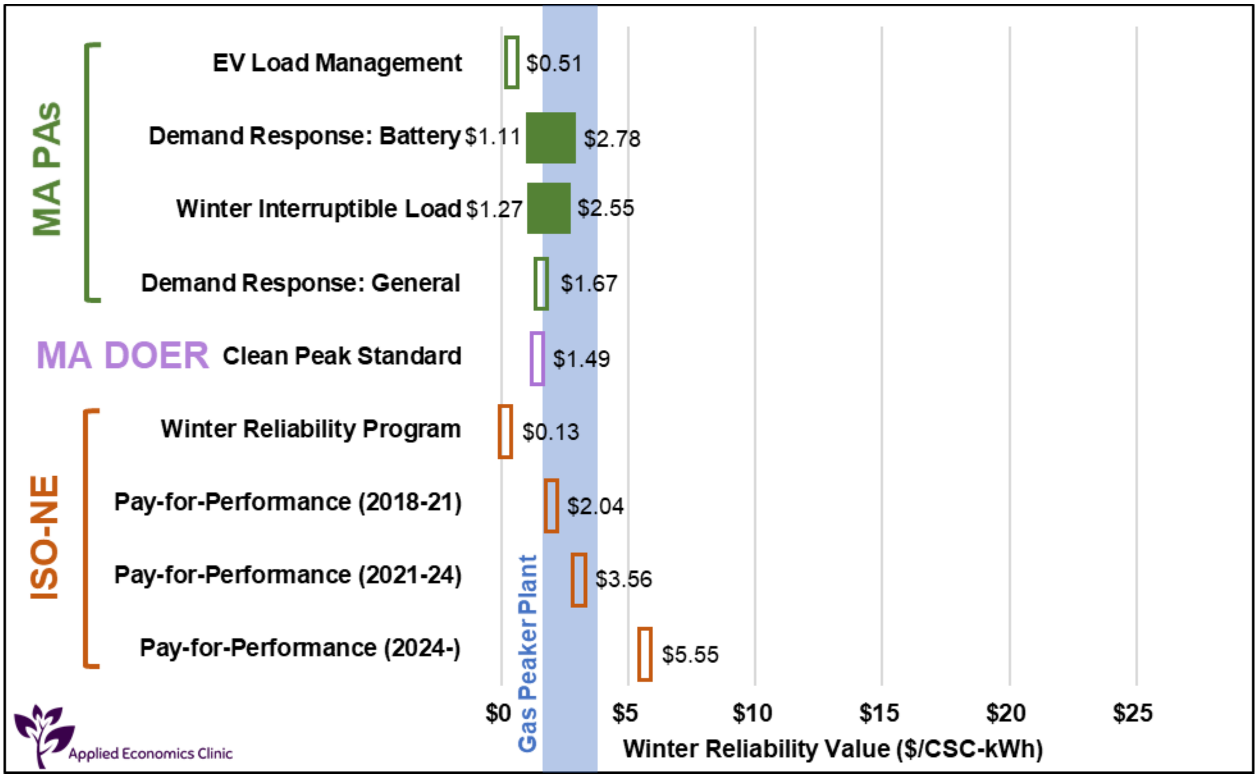
Table 2. Peak management measures

Customer Performance Payments	Peak Supply Technologies
Electric Vehicle (EV) Load Management	Gas Peaker Plant
Winter Interuptible Load Curtailment	Electric Battery Storage
Demand Response	Solar Photovoltaics (PVs) with Battery Storage
Massachusetts Clean Peak Standard	Hydroelectric Pumped Storage
ISO-New England Winter Reliability Program	
ISO-New England Pay-for-Performance	

Figure 4 compares the cost per unit of winter reliability ($ per CSC-kWh) of various regional customer incentive programs. All current performance payments for customer incentive programs in Massachusetts are equal to or less than the cost for new gas peakers to provide winter reliability, with costs ranging from $0.51 to $2.78 per CSC-kWh (as compared to the gas peaker range of $1.79 to $3.94 per CSC-kWh). The highest performance payment values in Figure 4 are for programs in future years while the gas peaker price range shown is for 2019.

[22] We focus on gas-fired peakers because they are by far the most common fossil-fuel peakers in New England, and the least expensive.

Figure 4. Peak management performance payments available to customers in Massachusetts ($/CSC-kWh)



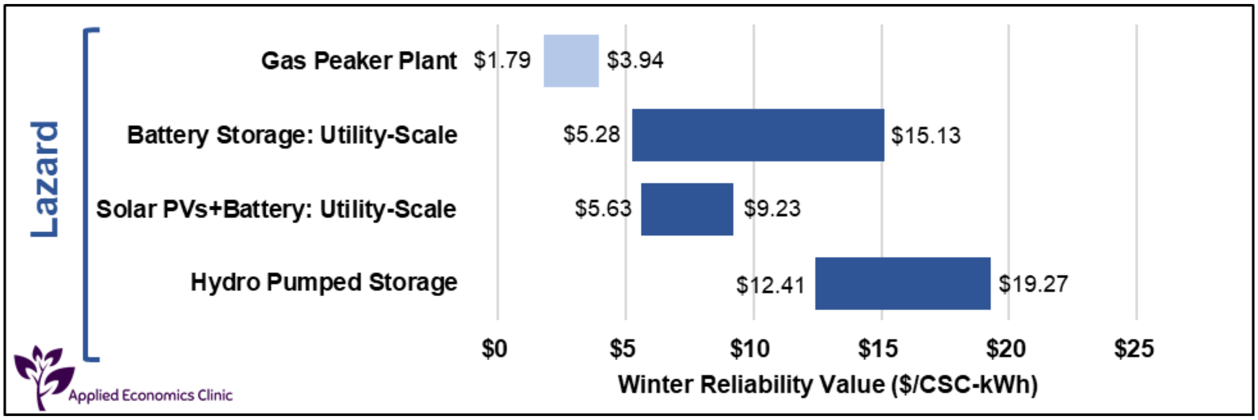
Data source: See in-text citations in. Massachusetts' ConnectedSolutions program is referred to here as "Demand Response: Battery" and "Demand Response: General".

It should come as no surprise that New England's winter reliability incentive programs (not to be confused with the ISO-New England "Winter Reliability Program," which is just one of the measures considered) have a similar cost to that of gas peakers: Most of the performance payments offered to customers were assigned based on the net costs of gas peakers.[23] In essence, program sponsors are willing to pay an incentive to get customer-sourced winter reliability (from demand response and/or batteries) that is no greater than the amount they would pay for the next cheapest alternative: gas peakers.

Among large-scale peak supply technologies, gas peakers are currently the least expensive option ($1.79 to $3.94 per CSC-kWh) (see Figure 5). ***Electric distributors are designing their customer performance payments to meet, but not exceed, the cheapest large-scale supply alternative.***

[23] Gas peaker costs in CSC-kWh are applicable to both newly built and existing gas combustion turbines that are still operating within their expected economic lifetime.

Figure 5. Large-scale supply technologies for serving winter peak ($/CSC-kWh)



Data source: See in-text citations in Appendix: Methodology and Assumptions

Gas peakers are exiting the Massachusetts generation portfolio

In August 2017, the Massachusetts Executive Office of Environmental Affairs and the Massachusetts Department of Environmental Protection published the following two regulations:

- 310 CMR 7.74: *Reducing CO_2 Emissions from Electricity Generating Facilities*[24]
- 310 CMR 7.75: *Clean Energy Standard (CES)*[25]

Both of these regulations aim to reduce greenhouse gas emissions from the state's power plants. Regulation CMR 7.75 effectively expands the Commonwealth's Renewable Portfolio Standard, increasing the amount of zero-carbon electricity that electric distributors must purchase. Regulation 310 CMR 7.74 established two separate declining annual aggregate carbon dioxide (CO_2) emissions limits, one for existing electricity generating facilities and the other for new generators. The CO_2 emissions limit for new facilities has already been exceeded, which means that no additional CO_2-emitting power plants can be built in Massachusetts, including gas peakers, without exceeding the limit established by the statute. Even if gas peakers were built outside of Massachusetts to increase winter reliability in the region, they would still have to be accounted for in the state's greenhouse gas inventory such that Massachusetts remains compliant with the emissions limits set by the Global Warming Solutions Act (GWSA).[26] These statutes are both currently under review including a proposed acceleration of standards.[27]

Clearly, gas peakers are on their way out in New England, and new, cost-effective resources—like customer-supplied peak capacity—are needed to take their place.

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[24] Massachusetts Department of Environmental Protection. "Electricity Generator Emissions Limits (310 CMR 7.74)." *Mass.gov.* Available at: https://www.mass.gov/guides/electricity-generator-emissions-limits-310-cmr-774

[25] Massachusetts Department of Environmental Protection. "Clean Energy Standard (310 CMR 7.75)." *Mass.gov.* Available at: https://www.mass.gov/guides/clean-energy-standard-310-cmr-775

[26] Massachusetts Department of Environmental Protection. July 2016. *Statewide Greenhouse Gas Emissions Level: 1990 Baseline and 2020 Business As Usual Projection Update*. p.13. Available at: https://www.mass.gov/doc/statewide-greenhouse-gas-ghg-emissions-baseline-projection-update-including-appendices-a-b/download

[27] See 2021 Program Review Stakeholder Discussion Document at https://www.mass.gov/doc/310-cmr-774-775-electricity-sector-program-review/download.

Continuing to index customer performance payments to gas peaker costs sets customer incentives artificially low

With gas peakers no longer an option for supplying future winter peak demand, electric distributors should be willing to pay customers with grid-connected batteries higher program performance payments, up to the cost of the next-cheapest large-scale peak supply option: utility-scale battery storage and solar PV plus battery resources, which have a winter reliability cost of $5.28 to $15.13 per CSC-kWh, depending on equipment and installation costs. In other words, when gas peakers are not available, ***electric distributors should be willing to pay at least $5.28 per CSC-kWh in customer performance payments, and perhaps more.***

Continuing to set customer performance payment rates based on the cost of gas peakers, when Massachusetts energy officials and regulators have declared gas peakers too dirty to be allowed to remain in the Commonwealth's generation portfolio, has the effect of setting customer performance payment rates artificially low.

Raising customer performance payment rates is not only fair, but also necessary to increase enrollment in ConnectedSolutions and similar demand response programs—and increased enrollment will be critical for the state to meet its growing winter reliability needs.

It may be argued that since customer enrollment in ConnectedSolutions, for example, is growing, there is no need to increase performance payment rates – but this assumes that early adopters are representative electric customers when, by definition, they are not. It is true that some customers will have non-financial motivations to bridge the gap between their investment and the performance payments: a desire for a secure backup power supply during a storm or other outage, for example, or an interest in contributing to the reduction of greenhouse gas emissions. These non-financial motivations have a role to play in the success to date of New England's battery incentive programs in securing peak demand reductions at the current low performance payment rates. But it is not realistic to expect these programs to be able to expand enrollment substantially simply by relying on such non-monetary motivations. Without more significant economic incentives, the success of these programs is limited. Higher performance payments would bring more participants into these programs, resulting in more customer-supplied winter peak resources.

Emissions limits will raise the supply of customer-owned capacity resources

These observations lead to an additional conclusion: Emissions limits applied to gas peakers in other states will tend to increase the supply of customer-owned capacity resources, including battery storage, if there is a mechanism like ConnectedSolutions that allows those customer-owned resources to provide grid services and be compensated for doing so.

When, as a consequence of emissions limits, gas peakers are no longer an option for meeting peak electric demand, electric distributors will find it economic to raise performance payment rates. Higher performance payments will increase customer participation in the programs and the amount of energy provided by customers at times of peak winter demand. The sooner capacity from gas peakers is limited by state or national law, the sooner performance payment rates for batteries will rise, thereby increasing program participation and customer supplied capacity resources.

V. Policy Recommendations

Based on our analysis of the relative pricing of winter reliability services in Massachusetts and the phase-out of gas (and other fossil-fueled) peaker plants from the state's electric generation portfolio, we make the following recommendations to the Commonwealth's policymakers, regulators, and program administrators:

1. **Customer battery performance payments should be increased by at least 33 percent. Customer battery program budgets should be increased to support higher performance payments and needed program expansion.** Customer-sited battery storage is by far the lowest-priced new winter peaking resource now available to utilities in Massachusetts, meaning that battery-owning (or leasing) customers who contract with utilities to supply capacity to the grid are being under-compensated for the services they provide. As the current portfolio of gas peaking plants is retired, more customer-sited batteries—the cheapest new winter peaking resource available—will be needed to replace them. The pace of this transition will accelerate with increasing electrification in the transportation and heating sectors, which will add to the need for winter peaking resources, and with the implementation of air emissions caps, which will hasten the retirement of existing greenhouse gas emitting peakers and prohibit the building of new fossil-fuel peakers to replace them.

   Although some customers may install batteries for non-monetary reasons, most will likely make this investment decision based largely on the economic return they can anticipate. Therefore, to convince more customers to install battery storage and provide peaking resources to the grid, higher customer performance payments will be required. Because smaller batteries provide the same service as larger ones, customers enrolled in battery incentive programs should be paid the same rate for winter reliability services that is paid to utility-scale battery owners—meaning customer performance payment rates for batteries should increase at least 33 percent above current levels. To accommodate these higher performance payment rates and enable the expansion of the Commonwealth's customer battery fleet, program budgets for ConnectedSolutions and similar programs should be significantly increased.

2. **The value of winter reliability services is greater than zero; the true value of these services should be calculated and used in cost-benefit analyses conducted by program administrators, and these values should be reflected in customer performance payments.** At present, the value of winter peaking capacity services from distributed (customer-sited) resources in battery program cost/benefit analyses is assumed to be $0 for the purposes of evaluation program economics and performance payment levels. However, as we have shown in this report, the true value of these services is greater than zero. A more realistic (and positive) value for winter reliability services should be calculated, and that value should be incorporated into battery program economics and reflected in customer performance payments. Assigning positive value to winter reliability services is critical to a correct assessment of the benefit winter peak resources bring to the region, and to an accurate allocation of funding towards customer performance payments on this basis. Furthermore, future dollar values for these customer performance payments should increase based on anticipated gas generator retirements and

growing customer needs for winter peak supply, driven by the increasing electrification of heating and transportation.

3. **The time to make positive changes to battery program performance payments and budgets is now.** Given the impending retirement of fossil-fueled peaker plants in Massachusetts, new, higher, customer battery performance payments and larger program budgets should be implemented immediately in the program administrators' 2022-2024 Three-Year Energy Efficiency Plan. This will allow for a smooth transition away from centralized fossil-fuel peaking resources, and toward customer-sited, non-emitting resources. It is important that electric distributors anticipate these changing market conditions by offering higher performance payments that will spur customer interest and participation. These changes should come in advance of gas peaker retirements, and not in their wake, to assure a well-organized and efficient transition to clean peaking winter energy supply.

Further research needs

Going forward, important areas for related research include:

- A specific valuation of winter reliability services, as separate from summer capacity
- Appropriate customer incentive levels as a consequence of this value
- The most cost-effective scale of incentive program budgets given their value and their costs, and taking into consideration upcoming retirements of emitting resources
- What other programs and regulations may require adjustment as a result of updated winter reliability values and customer performance payments

Appendix: Methodology and Assumptions[28]

To determine the monetary value of winter reliability, AEC considered six performance payment programs and four supply technologies for peak management. In this report, winter reliability is defined as the assurance of adequate electric capacity during periods of critical need called capacity scarcity condition (CSC) events.[29]

AEC calculated a winter reliability value measured as the cost on a per kilowatt-hour basis during the CSC period, a new metric introduced in this report that we denominate as $ per CSC-kWh (see Figure 6 below). Some of the peak management measures reviewed have associated CSC periods identifying the maximum number of winter hours in which there is a risk that supply will be insufficient to meet peak demand. For peak management measures that do not have a specified CSC period, AEC assumed a CSC period of 20 hours based on the Massachusetts energy efficiency program administrators' 2019-2021 three-year plan.[30]

Customer Performance Payments

Electric Vehicle (EV) Load Management

In the Massachusetts program administrators' 2019-2021 Three-Year Energy Efficiency Plan, EV load management aims to provide performance payments to shift EV charging away from hours of peak electric demand by scheduling charging during specific time periods. Programs manage EV charging through a centralized control system or an advanced/smart grid.[31]

- Winter Reliability Value: $0.51/CSC-kWh[32]
  The seasonal value ($/kW-yr) for winter EV load management is the Massachusetts energy efficiency program administrator's performance payment for this measure ($) divided by the maximum load reduction in kilowatts (kW). The winter reliability value ($/CSC-kWh) for this peak management measure is the calculated capacity value divided by the 20-hour CSC period (i.e., the maximum amount of time needed for winter reliability over multiple events in one season) specified for this program.[33]

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[28] The analysis described here is based on the resources available by November 2019. In some cases, new versions of some publication are now available. Ongoing analysis is needed to provide up-to-date benefit values as programs and forecasts continually evolve.

[29] We borrow this terminology from ISO-New England, which defines a "capacity scarcity condition" as an event in which the ISO is unable to meet one or more of its reserve requirements. ISO-NE. 2018. "2018 Annual Markets Report". Available at: https://www.iso-ne.com/static-assets/documents/2019/05/2018-annual-markets-report.pdf.

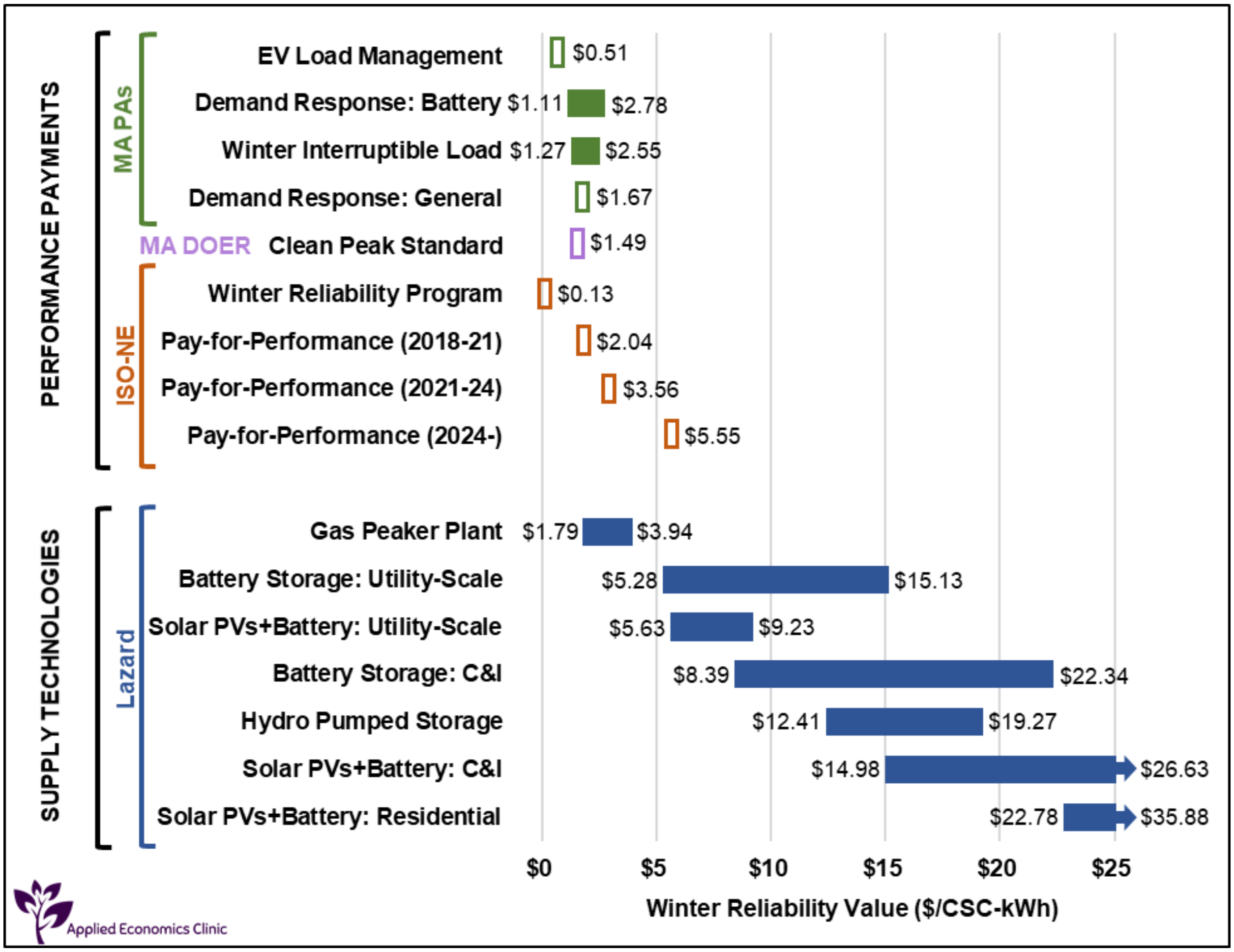
[30] Massachusetts Department of Public Utilities. Docket Nos. 18-116, 18-117, 18-118, 18-119. *Three Year Energy Efficiency Plan for 2019 through 2021*. October 31, 2018. BCR Spreadsheet submitted with "Massachusetts Joint Statewide Electric and Gas Three Year Energy Efficiency Plan: 2019-2021". Available at: http://ma-eeac.org/wordpress/wp-content/uploads/Exh.-1- Final-Plan-10-31-18-With-Appendices-no-bulk.pdf

[31] MassDPU. Docket Nos. 18-116, 18-117, 18-118, 18-119. P.364-5.

[32] All dollar values presented in 2019 dollars, converted (when necessary) using the CPI-U.

[33] MassDPU. Docket Nos. 18-116, 18-117, 18-118, 18-119.

Figure 6. Peak management performance payments and supply technologies ($/CSC-kWh)



Data source: See in-text citations in below.

Winter Interruptible Load Curtailment

In the Massachusetts program administrators' 2019-2021 Three-Year Energy Efficiency Plan, interruptible load curtailment aims to provide performance payments for commercial and industrial customers to curtail load during system peak conditions. In winter, interruptible load curtailment performance payments will be offered to customers that employ active demand reduction strategies during critical load events.[34]

- Winter Reliability Value: $1.27-$2.55/CSC-kWh
  The seasonal value ($/kW-yr) for winter interruptible load is the Massachusetts energy efficiency program administrators' performance payment for this measure ($) divided by the maximum load reduction in kilowatts (kW). The winter reliability value ($/CSC-kWh) for this peak management measure is the calculated capacity value divided by the 20-hour CSC period specified for this program.

[34] MassDPU. Docket Nos. 18-116, 18-117, 18-118, 18-119. p.122

Demand Response ("ConnectedSolutions")

In Mass Save's ConnectedSolutions program, demand response provides performance payments for customers to curtail their energy use during system peak conditions. Battery-specific demand response provides performance payments to customers to reduce net energy use by discharging a battery system when electric demand is at its peak. The ConnectedSolutions program is available to residential, commercial, and industrial customers of Massachusetts electric distributors. Enrolled customers are compensated on a pay-for-performance basis for their average kW curtailment during utility-defined peak demand events each season.[35]

- Winter Reliability Value (Battery-Specific): $1.11-$2.78/CSC-kWh
  The seasonal value for battery-specific demand response is the Massachusetts program administrators' performance payment ($/kW-winter). The winter reliability value for this peak management measure is the calculated capacity value divided by the 45-hour CSC period specified for small-scale batteries[36] and the 18-hour CSC period specified for commercial- and industrial-scale batteries[37] (maximum number of events multiplied by maximum event duration).
- Winter Reliability Value (General): $1.67/CSC-kWh
  The seasonal value for general demand response is the Massachusetts program administrators' performance payment ($/kW-winter).[38] The winter reliability value for this peak management measure is the calculated capacity value divided by the 15-hour CSC period specified for this program (maximum number of events multiplied by maximum event duration).

Massachusetts Clean Peak Standard

Massachusetts' Clean Peak Energy Portfolio Standard aims to increase the share of clean energy in the state's energy portfolio during times of peak electricity demand by introducing a minimum clean peak standard, or a percentage target of clean energy required during high demand periods. The policy also aims to improve grid reliability and reduce peak demand and system losses. Generators may participate in the program on a voluntary basis.[39]

- Winter Reliability Value: $1.49/CSC-kWh
  The winter reliability value ($/CSC-kWh) for the Massachusetts Clean Peak Standard is the Massachusetts Department of Energy Resources' alternative compliance payment rate for this program for 2020 multiplied by the appropriate Clean Peak Energy Certificate Multipliers—including the seasonal multiplier of 3 for winter, the resilience multiplier of 1.5, and the actual monthly system peak multiplier of 15.[40]

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[35] Mass Save. 2019. *Program Materials for ConnectedSolutions for Commercial / Industrial Customers*. Mass Save. Available at: https://www.nationalgridus.com/media/pdfs/bus-ways-to-save/connectedsolutions-programmaterials.pdf

[36] Mass Save. 2019. *Program Materials for ConnectedSolutions for Small Scale Batteries - Version 16*. This 2019 document is no longer available on Mass Save's website.

[37] Mass Save. 2019. Program Materials for ConnectedSolutions for Commercial / Industrial Customers.

[38] Mass Save. 2019. Program Materials for ConnectedSolutions for Commercial / Industrial Customers.

[39] Massachusetts Department of Energy Resources. 2018. Clean Peak Energy Portfolio Standard (CPS). 225 CMR 21.00. Available at: https://www.mass.gov/doc/225-cmr-21-clean-peak-standard-regulation/download

[40] Massachusetts Department of Energy Resources. 2018. Clean Peak Energy Portfolio Standard (CPS). 225 CMR 21.00. Available at: https://www.mass.gov/doc/225-cmr-21-clean-peak-standard-regulation/download

ISO-New England Winter Reliability Program

ISO-New England's now-defunct Winter Reliability Program (which is distinct from the "winter reliability" benefits used in energy efficiency program administrators' program evaluations) offered performance payments for five years (2013-2014 winter season to 2017-2018 winter season) to address electric reliability issues on the coldest days of the year. In addition to compensating oil and gas generators for securing fuel in advance of winter, the program simultaneously increased performance payments for demand-response resources to reduce the winter electric peak. This program was designed as a stopgap measure to allow for ISO-New England to develop longer-term market-based solutions.[41]

- Winter Reliability Value: $0.13/CSC-kWh
  The seasonal value ($/kW-yr) for the ISO-New England Winter Reliability Program is the average payment rate for the program's last three years.[42] The winter reliability value ($/CSC-kWh) for this peak management measure is the calculated capacity value divided by the calculated CSC period of 28 hours for this program—inferred from the number of hours paid out in each of the past three years.

ISO-New England Pay-for-Performance

ISO-New England's current Pay-for-Performance incentives went into effect on June 1, 2018 as a part of the region's Forward Capacity Market design, which aims to improve system reliability by adequately compensating resources for meeting their capacity supply obligations. These performance payments are employed using a two-settlement system, where underperforming resources pay a penalty that is used to compensate the overperforming resources that covered the corresponding deficit. [43]

- Winter Reliability Value (6/2018-5/2021): $2.04/CSC-kWh
- Winter Reliability Value (6/2021-5/2024): $3.56/CSC-kWh
- Winter Reliability Value (6/2024-): $5.55/CSC-kWh
  The winter reliability value ($/CSC-kWh) for ISO-NE's Pay-for-Performance incentives is the performance payment rate for each time period listed above.[44]

Peak Supply Technologies

Peaking supply technologies receive revenues from energy and capacity payments, which have been accounted for in our calculations. The annualized energy payments ($/kW-yr) for all supply technologies are the price of energy ($0.057/kWh) in the top 10 percent of hours by load for Massachusetts

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[41] ISO-New England. 2018. *2017 Annual Markets Report.* Available at: https://www.iso-ne.com/static-assets/documents/2018/05/2017-annual-markets-report.pdf

[42] ISO-New England. n.d. "Winter Program Payment Rate". ISO-NE. Available at: https://www.iso-ne.com/markets-operations/markets/winter-program-payment-rate

[43] ISO-New England. June 11, 2018. "'Pay-for-Perfomance' capacity market incentives implemented as of June 1, 2018." ISO Newswire. Available at: http://isonewswire.com/updates/2018/6/11/pay-for-performance-capacity-market-incentives-implemented-a.html

[44] ISO-New England. June 11, 2018. "'Pay-for-Performance' capacity market incentives implemented as of June 1, 2018."

(averaged from 2020-2024) multiplied by the total hours of operation in a given year.[45] The annualized capacity payments ($/kW-yr) for all supply technologies are the clearing price ($3.80/kW-month) of ISO-NE's 13th Forward Capacity Auction (FCA #13) multiplied by 12 months.[46] The winter reliability values presented below are net of these energy and capacity payments.

Gas Peaker Plant

Gas peaker power plants are generators designed to quickly ramp up or shut down, providing energy when needed. Most gas peakers are combustion turbines with higher variable costs than plants designed to run more frequently.

- Winter Reliability Value: $1.79-$3.94/CSC-kWh
  The annual value ($/kW-yr) for a gas peaker plant is Lazard's levelized cost of energy (LCOE)[47] multiplied by its annual capacity factor (10 percent) less energy and capacity payments. The winter reliability value ($/CSC-kWh) for this peak management measure is the calculated capacity value divided by the assumed CSC period of 20 hours.

Electric Battery Storage

Electric battery storage allows electricity to be produced in one time period and used in another.[48] Examples of grid-connected batteries include Lithium-Ion, Flow Battery (Vanadium), Flow Battery (Zinc-Bromide), Lead-Acid, and Advanced Lead (Lead Carbon).[49] For the purposes of this analysis, AEC used Lithium-Ion, the dominant battery chemistry in the stationary battery market at this time.

- Winter Reliability Value (Utility-Scale): $5.28-$15.13/CSC-kWh
- Winter Reliability Value (Commercial & Industrial): $8.39-$22.34/CSC-kWh
  The annual value ($/kW-yr) for electric battery storage is Lazard's levelized cost of storage (LCOS)[50] less energy and capacity payments. The winter reliability value ($/CSC-kWh) for this peak management measure is the calculated capacity value divided by the assumed CSC period of 20 hours.[51]

Solar Photovoltaics (PVs) with Battery Storage

PVs can generate energy that can supply the grid, or—if paired with storage—charge an electric battery for later use. When demand rises, the paired battery can discharge as needed to meet demand.

- Winter Reliability Value (Utility-Scale): $5.63-$9.23/CSC-kWh
- Winter Reliability Value (Commercial & Industrial): $14.98-$26.63/CSC-kWh

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[45] Synapse Energy Economics. October 2018. AESC 2018 User Interface (Main Case) Spreadsheet submitted with "Avoided Energy Supply Components in New England." Available at: https://www.synapse-energy.com/sites/default/files/AESC-2018-17-080-Oct-ReRelease.pdf

[46] ISO-New England. n.d. "Markets." ISO-NE. Available at: https://www.iso-ne.com/about/key-stats/markets#fcaresults

[47] Lazard. 2019. "Levelized Cost of Energy Analysis Version 13.0". Available at: https://www.lazard.com/media/451086/lazards-levelized-cost-of-energy-version-130-vf.pdf

[48] Center for Sustainable Systems, University of Michigan. 2019. "U.S. Grid Energy Storage Factsheet." Pub. No. CSS15-17. Available at: http://css.umich.edu/sites/default/files/US%20Grid%20Energy%20Storage_CSS15-17_e2019.pdf

[49] Lazard. 2019. "Levelized Cost of Storage Analysis Version 5.0". Available at: https://www.lazard.com/media/451087/lazards-levelized-cost-of-storage-version-50-vf.pdf

[50] Lazard. 2019. "Levelized Cost of Storage Analysis Version 5.0".

[51] In this report, LCOE and LCOS are used solely as data inputs for analysis. They are not compared head-to-head.

- Winter Reliability Value (Residential): $22.78-$35.88/CSC-kWh
  The annual value ($/kW-yr) for solar PVs with battery storage is defined by Lazard's LCOS less energy and capacity payments. The winter reliability value ($/CSC-kWh) for this peak management measure is the calculated capacity value divided by the assumed CSC period of 20 hours.

Hydroelectric Pumped Storage

Hydroelectric pumped storage is charged by pumping water into an uphill reservoir during times of low demand, typically overnight. The water is then released downhill to power a conventional hydro turbine during periods of high electric demand.[52]

- Winter Reliability Value: $12.41-$19.27/CSC-kWh
  The annual value ($/kW-yr) for hydroelectric pumped storage is defined by Lazard's LCOS[53] multiplied by its annual capacity factor (350 operating day per year multiplied by a duration of 8 hours) less energy and capacity payments. The winter reliability value ($/CSC-kWh) for this peak management measure is the calculated capacity value divided by the assumed CSC period of 20 hours.

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52 Lazard. 2018. "Levelized Cost of Storage Version 4.0". Available at: https://www.lazard.com/media/450774/lazards-levelized-cost-of-storage-version-40-vfinal.pdf

53 Lazard. 2016. "Levelized Cost of Storage Version 2.0". Available at: https://www.lazard.com/media/438042/lazard-levelized-cost-of-storage-v20.pdf

Energy Storage for Winter Grid Reliability

HOW BATTERIES BECAME THE LOW-COST SOLUTION FOR POWER ASSURANCE IN MASSACHUSETTS

Clean Energy Group (CEG) is a leading national, nonprofit advocacy organization working on innovative policy, technology, and finance strategies in the areas of clean energy and climate change.

CEG's energy storage policy work is focused on the advancement of state, federal, and local policies that support increased deployment of energy storage technologies. Battery storage technologies are critical to accelerate the clean energy transition, to enable a more reliable and efficient electric power system, and to promote greater energy equity, health, and resilience for all communities.

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