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Battery Storage for Fossil-Fueled Peaker Plant Replacement

A MAINE CASE STUDY

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ABOUT THIS REPORT

This case study was prepared by staff at the Clean Energy States Alliance (CESA). Established in 2002, CESA is a national, member-supported nonprofit that works with its members to develop and implement effective clean energy policies and programs. This case study is based on analysis conducted by Stratagen Consulting on CESA's behalf. The analysis focuses on the comparative cost-effectiveness of procuring energy storage to replace retiring fossil-fueled peaker plants, using Maine as a case study. A version of this report was submitted to the Maine Governor's Energy Office as stakeholder input to help inform Maine's development of a 200-megawatt utility-scale energy storage procurement program. The purpose of this analysis and report is to demonstrate to the State of Maine and other states how energy storage can cost-effectively replace fossil-fueled peaker plants, helping states to meet their decarbonization goals.

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ABOUT STRATEGEN CONSULTING

Strategen is a mission-driven consulting firm focused on activating a clean energy future that creates thriving businesses, economies, and people. Strategen's team leverages a global perspective and market-leading capabilities to deliver high-impact approaches across the policy, regulatory, and market design spheres that sustainably accelerate the deployment of low-carbon energy systems.

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The Bucksport Generation Power Station is a gas-fired peaker power plant at the site of the former Verso Paper Mill in Bucksport, Maine.

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Executive Summary

Increasingly, energy capacity provision and load reduction to meet peak electric grid demand have emerged as primary applications for commercially available, short-duration energy storage (primarily, lithium-ion batteries). At the same time, state decarbonization targets and equity concerns have focused attention on fossil-fueled "peaker" plants, which tend to be both costly and inefficient, and are disproportionately sited in low-income and historically underserved communities. Peakers and their associated air emissions—carbon dioxide (CO_2), nitrogen oxides (NO_x), sulfur oxides (SO_x) and fine particulates—create negative environmental and human health impacts.[1] The convergence of a viable market for battery storage with the need to retire aging fossil-fueled peaker plants has created a new interest in the economic and technical viability of replacing old gas and oil peakers with new battery energy storage systems (BESS).

Clean Energy States Alliance (CESA) undertook this analysis of the comparative cost effectiveness of procuring energy storage to replace retiring fossil-fueled peaker plants, focusing on Maine as a case study. The state of Maine has embarked on a transformative journey toward a more sustainable and resilient energy future. In response to Legislative Document (LD) 528, the Maine Governor's Energy Office (GEO) undertook a comprehensive energy storage market assessment in 2022. This assessment revealed that as solar penetration continues to rise, energy storage will play a pivotal role in system peak shaving, presenting a valuable solution to enhance the grid's reliability. Maine has established the ambitious target of 300 megawatts (MW) of energy storage by 2025 and 400 MW by 2030, as outlined in LD 528. The GEO is tasked with developing an energy storage procurement program designed to procure 200 MW of new, utility-scale battery storage.

This assessment revealed that as solar penetration continues to rise, energy storage will play a pivotal role in system peak shaving, presenting a valuable solution to enhance the grid's reliability.

In support of Maine's efforts, CESA contracted with Strategen Consulting to investigate whether one or more of the state's existing fossil-fueled peaker plants could be economically replaced by BESS. This analysis weighs the costs of installing up to 200 MW of new, grid-connected, utility-scale BESS of either 2-hour or 4-hour duration, as compared to the costs of installing new gas peakers to replace soon-to-retire legacy plants.

The analysis considers not only the relative costs of various new capacity assets, but also looks at the revenue impacts of performance requirements in the current regional capacity market as well as future performance requirements should ISO-New England switch to an Effective Load Carrying Capability (ELCC) model for its capacity market. Under an ELCC model, shorter-duration storage resources would be derated for purposes of bidding into the capacity market, while longer-duration resources would be valued at close to their nameplate capacity. Crucially, the analysis also delves into the emissions impacts of replacing aging fossil-fueled peakers with new gas peakers vs. BESS. This provides insights into the societal costs and benefits associated with the replacement of incumbent peaking capacity.

1 CESA's sister organization, Clean Energy Group (CEG), conducts a Phase Out Peakers program dedicated to advancing battery storage as an alternative to fossil-fueled peaker plants and their adverse community impacts. For more information see https://www.cleanegroup.org/initiatives/phase-out-peakers.

The Cape Gas Turbine in South Portland was built in 1970 as a simple cycle gas-turbine facility, with a capacity of 35 MW. Photo: Image Capture, June 2019, © 2024 Google.

In order to compare the cost of new gas peakers vs. new BESS, the analysis relies on assumptions including projected future fuel costs as well as future capital costs for new F-frame gas peakers[2] and new battery storage systems. The technology costs both for batteries and new peakers come from NREL's Annual Technology Baseline (ATB). Since gas peakers are a well-developed technology, projections of future prices do not vary as much as projections of future battery prices. The battery pricing used in the model reflects the expectation that the market development resulting from clean energy targets and federal incentives will accelerate the reduction of battery costs.[3] The price is a projection of the cost to deploy and maintain a BESS over the projected 30-year lifetime of a new gas peaker (including battery replacement at 15 years).

Replacing fossil-fueled peaker plants with battery storage would avoid this increase in emissions, resulting in environmental and human health benefits including lower risks of respiratory illness, cancer, disease, and premature mortality associated with the emission of greenhouse gases (GHG) such as CO_2 and local pollutants such as SO_2 and NO_x.

The analysis also considers the costs of emissions associated with new gas peaking capacity. If the most inefficient and aging fossil-fueled peakers in Maine were retired and replaced with new, more efficient gas plants, Maine would see an increase in total emissions of about 104,000 tons of CO_2, 12 tons of NO_x, and 0.5 tons of SO_2. This increase in emissions occurs because the new gas plants would be able to economically run for more hours per year than the existing, aged fossil-fueled plants; and more run-time results in higher emissions,

2 An F-frame peaker, part of the F-Class technology, typically ranges in size from 170 to 230 MW. F-Class turbines have been notable players in the North America 60 Hz heavy-duty gas turbine market for over 20 years; as such, they are the typical peaker type that would likely be built.

3 The analysis also included sensitivity testing of the impacts on net costs of variables including future technology cost decline rates, fuel costs, carbon policies, and electrification progress. These values were taken from public sources such as NREL, EIA, and ISO-NE. The expected scenario assumes an advanced rate of technology development for both storage and peakers, based on historical market progress (note that more conservative assumptions increase the net cost of storage in both the QC and ELCC cases, resulting in a different outcome).

despite the increased efficiencies of the newer plants. Replacing fossil-fueled peaker plants with battery storage would avoid this increase in emissions, resulting in environmental and human health benefits including lower risks of respiratory illness, cancer, disease, and premature mortality associated with the emission of greenhouse gases (GHG) such as CO_2 and local pollutants such as SO_2 and NO_X. These emissions reductions would save Maine an estimated $7.1 million annually by 2030 based on the morbidity and mortality of NO_X and SO_2 and precursors of fine particulate matter ($PM_{2.5}$).[4]

The analyses conducted for this report show that when local and global emissions impacts are taken into account, 4-hour BESS is more cost-effective than new gas peakers under both current Qualifying Capacity (QC) and prospective Effective Load Carrying Capability (ELCC) ISO-New England capacity market accreditation rules. Crucially, 4-hour BESS is also significantly more cost-effective than its 2-hour counterpart under the ELCC approach, making 4-hour BESS a more durable, future-proof investment (see Table ES-1).

Table ES 1

New Asset Net Cost Comparison for Qualifying Capacity (QC) and Effective Load Carrying Capability (ELCC)

Qualifying Capacity		Effective Load Carrying Capability	
Asset	Net Cost ($/kW-month)	Asset	Net Cost ($/kW-month)
BESS, 2-hr	(0.54)	BESS, 4-hr	2.63
BESS, 4-hr	2.42	New F-Frame	3.10
New F-Frame	3.10	BESS, 2-hr	3.12

Source: Strategen Consulting

Based on this result, a new front-of-the-meter (FTM) BESS procurement framework in New England should focus on the deployment of longer-duration assets, starting with 4-hour BESS. In Maine, the most likely targets for retirement and replacement are the aging Cape Gas (40 MW) and either Verso (183 MW) or Wyman Unit 3 (114 MW) fossil-fueled peakers. These three plants are old and have extremely low capacity factors, which bolsters the feasibility of their replacement with BESS.

It is our hope that these findings and recommendations may serve as a roadmap for Maine policymakers as well as for other states looking to meet their decarbonization and energy storage procurement targets, while maximizing the environmental and economic benefits associated with a forward-looking, grid-integrated approach.

4 The authors' dispatch model simulates economic dispatch of peakers based on historical energy and ancillary services prices. The emissions values were derived from the authors' projection of local SO_2 and NO_x emissions from each plant. The average health costs of those pollutants in urban areas were obtained from "Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide. Interim Estimates under Executive Order 13990," U.S. Government Interagency Working Group on Social Cost of Greenhouse Gases, February 2021. See https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf. Cost numbers have been adjusted for inflation.

Background

The state of Maine has embarked on a transformative journey toward a more sustainable and resilient energy future. In response to LD 528, the Governor's Energy Office undertook a comprehensive energy storage market assessment in 2022. This evaluation revealed that, as solar penetration continues to rise, battery energy storage systems (BESS) play a pivotal role in system peak shaving, presenting a valuable solution to enhance the grid's reliability. The assessment identified that, by 2025, grid-connected BESS in Maine would be cost effective.[5] With an ambitious target of 300 MW of energy storage by 2025 and 400 MW by 2030, as outlined in LD 528, Maine is proactively positioning itself as a trailblazer in the adoption of energy storage technologies.

With an ambitious target of 300 MW of energy storage by 2025 and 400 MW by 2030, as outlined in LD 528, Maine is proactively positioning itself as a trailblazer in the adoption of energy storage technologies.

In this context, Clean Energy States Alliance (CESA) contracted Strategen Consulting to assess the technical and economic feasibility of replacing fossil-fueled peaker capacity in Maine with up to 200 MW of grid-connected utility-scale BESS. This endeavor aligns with Maine's ongoing efforts, which include the imminent development of a 200 MW front-of-the-meter (FTM) BESS procurement program.

Currently, the state boasts approximately 50 MW of BESS capacity, with an additional 225 MW slated to come online by 2025. The longest duration of installed resources is two hours, which is currently enough to participate in the Independent System Operator of New England's (ISO-NE) forward capacity market (FCM).[6] While current rules incent the two-hour duration, ISO-NE is considering modifying its capacity accreditation rules to an effective load-carrying capability (ELCC) framework, in which short-duration storage is likely to receive diminishing valuation and payments.[7]

Maine is close to meeting its 2025 energy storage target, but storage resources with longer duration might be needed to replace existing fossil-fueled peaking capacity given potential changes to the capacity accreditation mechanisms. As such, this analysis includes consideration of both 2-hour and 4-hour BESS under different capacity accreditation methods. As Maine approaches its 2025 energy storage target, this analysis will be important in guiding strategic decisions regarding the replacement of aging fossil-fueled capacity.

This report compares the net cost of various approaches to replacing aging fossil-fueled peaking assets, weighing the options between installing new gas peaker assets or adopting BESS of varying durations. Crucially, the analysis also considers the emissions-related costs of new gas peakers, providing insights into the societal benefits associated with replacement of retiring fossil-fueled generation capacity with clean BESS.

5 E3, Maine Energy Storage Market Assessment, March 2022, at 44.

6 While other markets for peaker and BESS services exist, such as ancillary services markets, the regional forward capacity market represents the main application and source of revenue for these assets.

7 ISO-NE's Alternative FCM Commitment Horizons Key Project includes interrelated efforts that consider changing the timing and commitment horizons of FCM auctions to adequately prepare for the evolving electric power resource mix and expected clean energy system. See GE, 2022. Evaluation of ELCC Methodology in the ISO-NE Footprint.

The soon-to-be started Cross Town Energy Storage Project will be a 175 MW/350 MWh battery storage project located in the town of Gorham, Maine. Artist Rendering courtesy of Plus Power.

The recommendations herein may serve as a roadmap for Maine policymakers, helping to ensure that the state not only meets its energy storage targets but also maximizes the environmental and economic advantages associated with a forward-looking, grid-integrated approach. Moreover, they also should provide a basis for similar peaker-replacement efforts in other states.

Methodology

Strategen performed an analysis to evaluate the costs of replacing aging fossil-fueled peaker plants in Maine with new and more efficient flexible technologies, including energy storage of different durations and new natural gas peaker options. The analysis focused on a comparison of the net costs associated with both technologies to provide equivalent capacity under two future scenarios of capacity accreditation. First, the current qualified capacity framework under which a 2-hour BESS qualifies for full capacity value and payments. Second, an ELCC framework, as the expected result of the current ISO efforts to update the rules of its capacity market, where there is a decreasing capacity accreditation for BESS. Under the ELCC case, 4-hour BESS is accredited for 99.6%–100% of its installed capacity in 2028, a value that decreases to 56%–73% by 2040.[8] Similarly, the ELCC case applies a linear duration discount to 2-hour storage, meaning the accredited capacity of 2-hour BESS would be significantly less under ELCC rules.

8 Storage maintaining a higher a capacity value in the future is correlated to the progress of electrification. GE, 2022. See Evaluation of ELCC Methodology in the ISO-NE Footprint.

The net cost was calculated as the difference between the costs of producing energy (capital, operating, and maintenance costs)[9] and the potential revenues in the ISO-NE day-ahead energy and ancillary service markets for each technology.[10] For the incumbent peakers, the net cost was approximated assuming that plants have already been paid off and therefore incur no additional capital costs; and that the plants would run economically—during hours when the wholesale energy prices are higher than the cost of energy dispatch.[11] A charge and discharge schedule was set for energy storage resources, allowing one daily cycle that maximizes profits from energy arbitrage. When not participating in the energy market, both peakers and energy storage were able to earn additional revenues from the ancillary services market in the form of spinning reserves, but revenues from frequency regulation were excluded as that market is expected to saturate in the near term.

When not participating in the energy market, both peakers and energy storage were able to earn additional revenues from the ancillary services market in the form of spinning reserves, but revenues from frequency regulation were excluded as that market is expected to saturate in the near term.

The capital cost of new assets includes assumptions about the cost of capital (7% weighted average cost of capital) and the useful life of each technology. The lifetime of BESS is projected and modeled to 15 years, with the costs of maintaining its rated capacity after degradation included in the maintenance costs. The new peaker is expected to have a useful life of 30 years, based on the average age of retirement of similar technology peaker plants in the US.[12] Importantly, the shorter life of the battery in the annualized cost comparison means that the battery could be replaced at a lower cost after 15 years, making it more cost-competitive and flexible in the long run.[13]

The analysis used data from ISO-NE, the Energy Information Administration (EIA), the National Renewable Energy Lab (NREL), and Standard & Poor's (S&P) data to create the sensitivities needed to understand the impact of variation in future technology costs, fuel costs, market rules, incentives, and taxes. The sensitivity analysis included three scenarios for technology cost decline over time as published in NREL's Annual Technology Baseline 2023,[14] and a 30% federal Investment Tax Credit (ITC) consistent with base benefits from the Inflation Reduction Act of 2022 (IRA).[15] Fuel price projections were sourced from EIA's 2023 Annual Energy Outlook, reflecting the reference and a higher fuel cost future resulting from reduced natural gas supply.[16] Finally,

9 Capital costs, fixed annual costs, and variable costs were sourced from the NREL Annual Technology Baseline for 2023. Accessible at https://atb.nrel.gov/electricity/2023/data.

10 Historical hourly prices were sourced from ISO-NE markets website, using 2023 prices as the basis for analysis.

11 Operating costs were determined by the heat rate for each unit, the annual projected price of natural gas, and expect operation and maintenance costs. The energy prices were based on historical local marginal prices (LMPs) from 2019, adjusted for inflation. To reduce complexity, associated revenues were estimated only for day-ahead markets under the assumption that peakers would not deviate from their day-ahead schedule.

12 Energy Information Agency (EIA), Preliminary Monthly Electric Generator Inventory (based on Form EIA-860M as a supplement to Form EIA-860), https://www.eia.gov/electricity/data/eia860m (accessed January 2024).

13 This result is based on the projected decline in battery costs.

14 Energy storage is represented using capital, operation and maintenance costs of lithium-ion batteries while the costs for the new peaker represent an F-frame natural gas combustion turbine. The cost scenarios represent three rates of cost decline from 2024 to 2050 (conservative, moderate and advanced).

15 The Inflation Reduction Act provides a 30% ITC benefit for energy storage, assuming sourcing and labor requirements are fulfilled.

16 The expected scenario uses the higher fuel cost scenario to reflect risks associated to the gas delivery system and advancing decarbonization policies at the federal level. Nonetheless, given the low utilization of peaker resources, the difference between fuel cost scenarios is not a major factor driving cost effectiveness in the comparison analysis.

operational costs of incumbent peakers were taken from S&P as reported by plant owners to the Environmental Protection Agency (EPA). Importantly, the analysis assumed that all capacity deployed in Maine can serve the needs of the capacity zone as defined by ISO-NE.[17]

The analysis accounts for peaker plant replacement occurring by 2025 to 2030, applying 2023 market prices. The universe of aging peakers considered for replacement includes five assets: the Cape Gas Turbine (40 MW), William F. Wyman 3 (114 MW) and 4 (605 MW) steam turbines, Verso Paper mill (183 MW), and the New Peaker F-Frame gas turbine (see Table 1). The two scenarios applied are based on type of capacity accreditation (ELCC or QC) and future fuel costs (Baseline, Low Oil and Gas Supply); additional modifiers include cost of carbon (Regional Greenhouse Gas Initiative [RGGI] and Social Cost of Carbon [SCC] at different discount rates: 5%, 3%, 2.5%, 2%), the federal investment tax credit (ITC) (30%, 40%, and 50%), battery cost (Advanced, Moderate, Conservative), and future electrification scenarios affecting ELCC values (Base, High).

Table 1
Summary of Existing Peakers Under Analysis

	William F. Wyman 3 & 4	Cape Gas Turbine	Verso Paper
Technology	Steam turbine, residual fuel oil	Gas turbines, distil-late fuel oil	Gas turbine, Natural gas and distillate fuel oil
Units (MW)	2 units (114 and 605 MW)	2 units (20 MW each)	1 unit (183 MW)
Age	59 and 46 years old	Both 54 years old	23 years old
Owner	NextEra	NextEra	JERA
Utility	CMP	CMP	CMP
Heat Rate (Btu/kWh)	10,990	20,730	12,300
2022 Capacity Factor (%)	3.3	0.1	0.6

Source: Strategen Consulting

Results

Results with externalized emissions-related costs

The net cost results[18] presented herein use these assumptions:

- Low Oil and Gas Supply for fuel costs
- a scalation of RGGI prices in line with historical trends
- a 30% ITC for BESS
- a 15-year lifetime for BESS and 30-year lifetime for new gas-fired peakers

17 ISO New England, Capacity Zone Development, accessed January 31, 2024, https://www.iso-ne.com/markets-operations/markets/forward-capacity-market/fcm-participation-guide/capacity-zone-development.

18 Net costs in this analysis represent the gap between the potential market revenues that each technology would earn and the cost of deploying, maintaining, and operating each asset. Market revenues are based on historical energy and ancillary service prices, adjusted for inflation, as well as a projection of capacity prices for the Maine area.

- a 7% weighted average cost of capital (WACC)
- a 2.5% average inflation rate
- Advanced (i.e., quicker cost decline) Cost projection for BESS
- High Electrification scenario[19]
- All costs and revenues are in 2024 dollars

As the only assumption that changes between analyses is the capacity accreditation assumption, the results shown in Table 2 are labeled QC or ELCC, respectively.

Table 2
Summary of Net Cost Results Under QC and ELCC Cases ($/kW-month)

QC		ELCC	
Asset	**Net Cost**	**Asset**	**Net Cost**
Verso	(5.56)	**Verso**	(5.56)
Cape Gas	(3.47)	**Cape Gas**	(3.47)
Wyman 4	(3.17)	**Wyman 4**	(3.17)
Wyman 3	(2.99)	**Wyman 3**	(2.99)
BESS, 2-hr	(0.54)	**New F-Frame**	1.87
New F-Frame	1.87	**BESS, 4-hr**	2.63
BESS, 4-hr	2.42	**BESS, 2-hr**	3.12

Source: Strategen Consulting

The results in Table 2 show that aging fossil-fueled resources continue to provide a source of cheap capacity given the fact that their capital costs have fully depreciated. As a result, existing peakers provide low-cost capacity but rarely dispatch given their high fuel and operational costs. Thus, these assets provide low system value on a day-to-day basis and externalize a significant share of their costs, as discussed in the Peaker Emission Impacts section of this report.

Under the QC case, existing peakers are joined by 2-hour BESS in the group of assets with negative net costs. This is mainly due to the Advanced Cost assumptions used and to the fact that, in the QC scenario, a 2-hour BESS is fully accredited for capacity. This result is significant for near-term replacement and incremental investments, as a 2-hour BESS is significantly more cost-effective than a new F-Frame peaker.

The relative cost-effectiveness of 4-hour storage is generally dependent on the capacity accreditation framework. While 4-hour BESS has the highest net cost under a QC framework, it is a significantly more cost-effective investment under the ELCC paradigm relative to a 2-hour asset. This underscores that while 2-hour resources might be viable in the near term, as the penetration of renewables and storage increases, longer duration assets such as 4-hour BESS represent more durable, future-proof investments.[20]

19 Note that results are sensitive to BESS cost projections. Using higher projected future BESS costs results in a different outcome. See Appendix C for this result.

20 This relationship is due to the increasing penetration of renewables and storage diluting these assets' marginal capacity contributions, a dynamic captured by the ELCC framework. With greater renewable and 2-hour storage penetration, the arbitrage opportunity requires increasing durations to capture price differentials, thus making 4-hour resources increasingly attractive and more durable investments.

The Bucksport Generation Power Station is a gas-fired peaker power plant at the site of the former Verso Paper Mill in Bucksport, Maine. Photo gkenmo/iStock

Notwithstanding the above, these results also show that, from a pure net-cost perspective, replacing aging capacity with a new F-Frame peaker could be seen as economic under some circumstances. It is important to note these net-cost results only consider expected revenues and costs and do not consider unmonetized externalities such as emissions. Because of this, a consideration of the additional emissions-related benefits of deploying BESS rather than a new F-Frame peaker is covered in the following section, "Results with internalized emissions-related costs."

While 2-hour resources might be viable in the near term, as the penetration of renewables and storage increases, longer duration assets such as 4-hour BESS represent more durable, future-proof investments.

Given their size and relative net costs, Strategen consulting and CESA consider that Cape Gas and Wyman Units 3 and 4 should be the focus of any potential replacement program. The figures detailing the net costs of all these plants, as well as 2-hour and 4-hour BESS under QC and ELCC, can be found in Appendix A.

Results with internalized emissions-related costs

The benefits of replacing existing fossil-fueled peaker capacity with cleaner alternatives are multiplied by the fact that a portion of the aging peaker capacity in Maine is in or near to urban areas, some of which are classified by the US EPA as disadvantaged communities (DACs). Cape Gas is a 40-MW peaker located in Portland, Maine, with approximately 74,000 people living within three miles from the plant, 64 percent of whom reside in DACs. William F. Wyman is a larger plant of 720 MW that is operating as a peaker plant due to high costs of fuel and operations. Wyman is located outside of Portland but still within three miles of 9,200 people living in the area, of whom 40 percent reside in DACs.

The emissions produced by fossil-fueled generators cause negative impacts on air quality and the health of local populations. The most common pollutants emitted from fossil-fueled plants are NO_X, SO_2, and CO_2. NO_X is a contributor to ozone, which can cause respiratory problems and other health and environmental impacts. SO_2 can also lead to respiratory damage, particularly for children and people with asthma, and is a precursor to small particulate matter such as $PM_{2.5}$, which can further impact the lungs because it penetrates deeper than larger particulates.

The retirement of aging fossil-fueled peaker plants in Maine, especially those located close to urban communities, presents an opportunity to reduce emissions and their adverse environmental and health impacts. However, this outcome depends on what these plants are replaced with.

Wyman Power Station is an oil-fired peaker power plant in Yarmouth, Maine.
Photo: NewTestLeper79/Wikimedia Commons CC BY-SA 4.0

For example, the retirement of the oldest and most inefficient peakers in the state's current fleet —the 114 MW Wyman unit and the two Cape Gas units (40 MW)—would reduce annual emissions by 9,700 tons of CO_2, 8.4 tons of NO_X, and 14.6 tons of SO_2. However, if they were replaced by new gas plants that can run economically more often, overall emissions would increase, with total emissions from the new, replacement plants of about 104,000 tons of CO_2, 12 tons of NO_X, and 0.5 tons of SO_2. This occurs because the new plants, being more efficient, could be run profitably more hours of the year than the existing plants. By contrast, replacement with energy storage will avoid these harmful emissions and therefore result in multiple environmental and human health benefits, such as lower risks of respiratory illness, cancer, disease, and premature mortality. These benefits can be quantified through the avoided cost of these impacts. Local emissions impacts from new natural gas power plants in Maine, sized to replace the retiring Wyman and Cape Gas units referenced above, would be expected to cost an estimated $7.1 million annually by 2030, based on the morbidity and mortality of NO_X and SO_2 as precursors of $PM_{2.5}$.

Replacement with energy storage will avoid these air emissions increases and therefore result in multiple environmental and human health benefits, such as lower risks of respiratory illness, cancer, disease, and premature mortality.

In addition to producing pollutants that can have localized impacts on health and mortality, fossil-fueled power plants produce global pollutants such as $C0_2$. Globally, power plant emissions cause damage by concentrating in the atmosphere and contribute to climate change world-wide, regardless of where the source of emissions is located. The harms from climate change lead to societal impacts related to net agricultural productivity, property damages from increased flood risks, human health impacts, energy system costs, and other aspects of the economy that are accounted for in the cost of carbon.

The U.S. Environmental Protection Agency (EPA) provides guidance on the social cost of carbon and discount rate parameters, which allows the calculation of the monetary value of climate change impacts caused by GHG emissions and the value of avoided damages.[21] Based on the EPA's guidelines, the 104,200 tons of CO_2 that could be emitted every year by a new 154 MW fossil-fueled peaker plant (sufficient to replace the existing capacity from the three most inefficient units mentioned above) would cost the world about $6.97 million annually by 2030 (see Table 3, p. 15).

Reduced reliance on fossil-fueled peaking plants in Maine would therefore offer substantial health and environmental benefits for communities in the state while also supporting the mitigation of climate change risks. When considering the societal and health impacts of developing a new gas-fired peaker asset, the net cost of a new F-frame increases significantly, from $1.87/kW-month to $3.1/kW-month (see Table 4, p. 15). This alters the relative net costs of the replacement alternatives for existing peaking capacity, positioning the 4-hour BESS as a more cost-effective option relative to a new F-Frame peaker. The figures detailing the net costs of these options, as well as 2- and 4-hour BESS under QC and ELCC, can be found in Appendix B.

21 U.S. Government Interagency Working Group on Social Cost of Greenhouse Gases, "Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide. Interim Estimates under Executive Order 13990," February 2021. https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf.

Table 3

Economic Impact of New Gas-Fired Plant Air Emissions in Maine (154 MW)[22]

Pollutant	Economic Value (2023$/ton)		Annual Emissions (Tons)	Annual Economic Impact by 2030 ($)
	2025	2030		
CO_2	$61	$67	104,200	$6,976,194
NO_x	$9,156	$10,259	12.6	$129,508
SO_2	$67,659	$76,361	0.5	$40,166
Total	$76,876	$86,687	104,213.1	$7,145,868

Source: Strategen Consulting

Table 4

Comparison of New Peaking Alternatives' Net Costs Under QC and ELCC Cases, Inclusive of Health and Societal Costs ($kW-month)

QC		ELCC	
Asset	Net Cost	Asset	Net Cost
BESS, 2-hr	(0.54)	BESS, 4-hr	2.63
BESS, 4-hr	2.42	New F-Frame	3.10
New F-Frame	3.10	BESS, 2-hr	3.12

Source: Strategen Consulting

Recommendations for a BESS Procurement Framework

Today, existing fossil-fueled peaker assets in Maine are aging and are seldom dispatched economically. As a result, many of these assets are likely to retire soon, making their replacement with cleaner alternatives timely as it would materially contribute to the reliability of the grid, as well as minimize the health and environmental impacts associated with fossil-fueled generation. The economic and societal impact analyses contained herein show that, in the expected scenario, a 4-hour BESS is more cost effective relative to a new gas peaker under both current and prospective capacity accreditation rules. Crucially, 4-hour BESS is also significantly more cost-effective than its 2-hour counterpart under the ELCC accreditation approach, making 4-hour BESS a more durable, futureproof investment.

The economic and societal impact analyses contained herein show that, in the expected scenario, a 4-hour BESS is more cost effective relative to a new gas peaker under both current and prospective capacity accreditation rules.

In this context, a BESS procurement framework should focus on the deployment of longer-duration assets, starting with 4-hour BESS.

22 Please note this table represents the impact of a new gas peaker asset (F-frame) in Maine with sufficient capacity to replace the two oldest existing peakers. This assumes a 153.8 MW asset dispatching at 15% capacity factor.

10.3 MW battery storage system owned by Brookfield Renewable located in East Millinocket, Maine, at the site of the former Great Northern Paper Mill. The nine Tesla Megapacks in this battery system have a capacity of 20 megawatt hours, about enough to power 9,000 homes for two hours.
Photo: Murray Carpenter/Maine Public.

A Maine energy storage procurement program should focus on the deployment of enough 4-hour BESS capacity to replace that provided by Cape Gas (40 MW) and Wyman Unit 3 (114 MW) or Verso (183 MW) assets. The feasibility of these replacements is further bolstered by the extremely low capacity factors of the existing peaking assets.

Importantly, it would not be necessary for new BESS to use the existing interconnection points of retiring fossil-fueled plants; this likely would be both burdensome and unnecessary, as peaking capacity at any location within Maine can contribute to the capacity requirements of the State per ISO-NE.

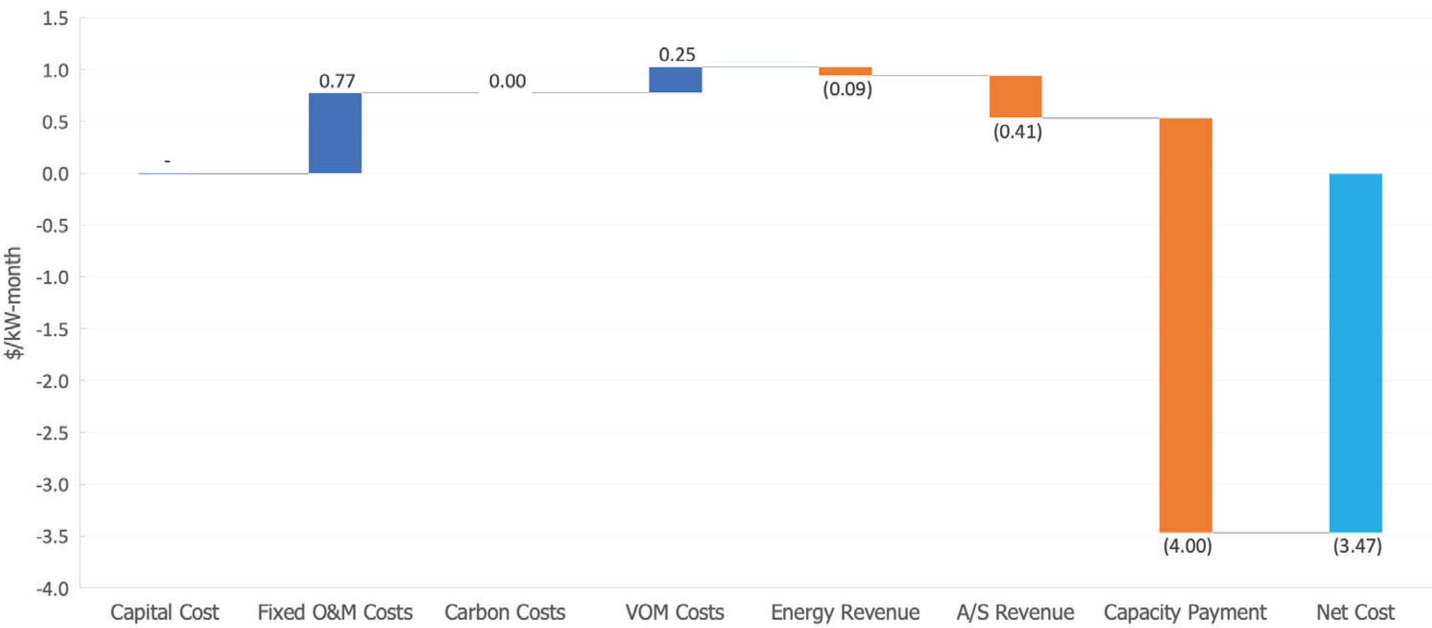
In conclusion, battery replacement of existing fossil-fueled peaker resources in Maine emerges as a timely and impactful strategy, not only for enhancing grid reliability by allowing for the use of excess renewable energy during periods of high demand, but also for mitigating the negative health and environmental impacts associated with aging fossil-fueled assets. By adopting these recommendations for peaker replacement, Maine can not only take a significant step toward meeting its energy storage targets, but also demonstrate a viable model for a resilient, sustainable, and economical clean energy future.

APPENDIX A

Net Cost Analysis Results Exclusive of Health and Societal Costs

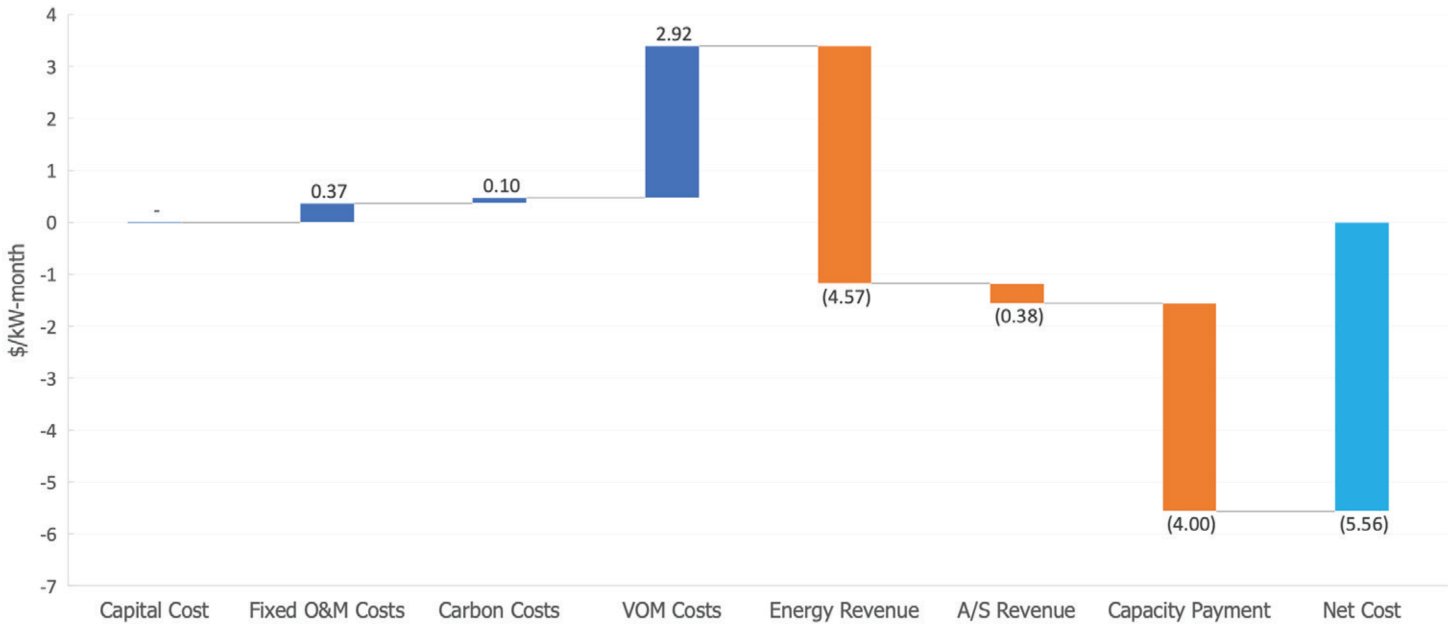
Appendix A shows the net costs of the incumbent (soon to retire) fossil-fueled peakers, compared to the net costs of replacement technologies, under both the current (QC) and presumed future (ELCC) capacity market rules. These results do NOT consider the costs associated with environmental and human health damage from fossil-fuel air emissions.

Figure A-1
Cape Gas Turbine Net Cost Analysis (QC)



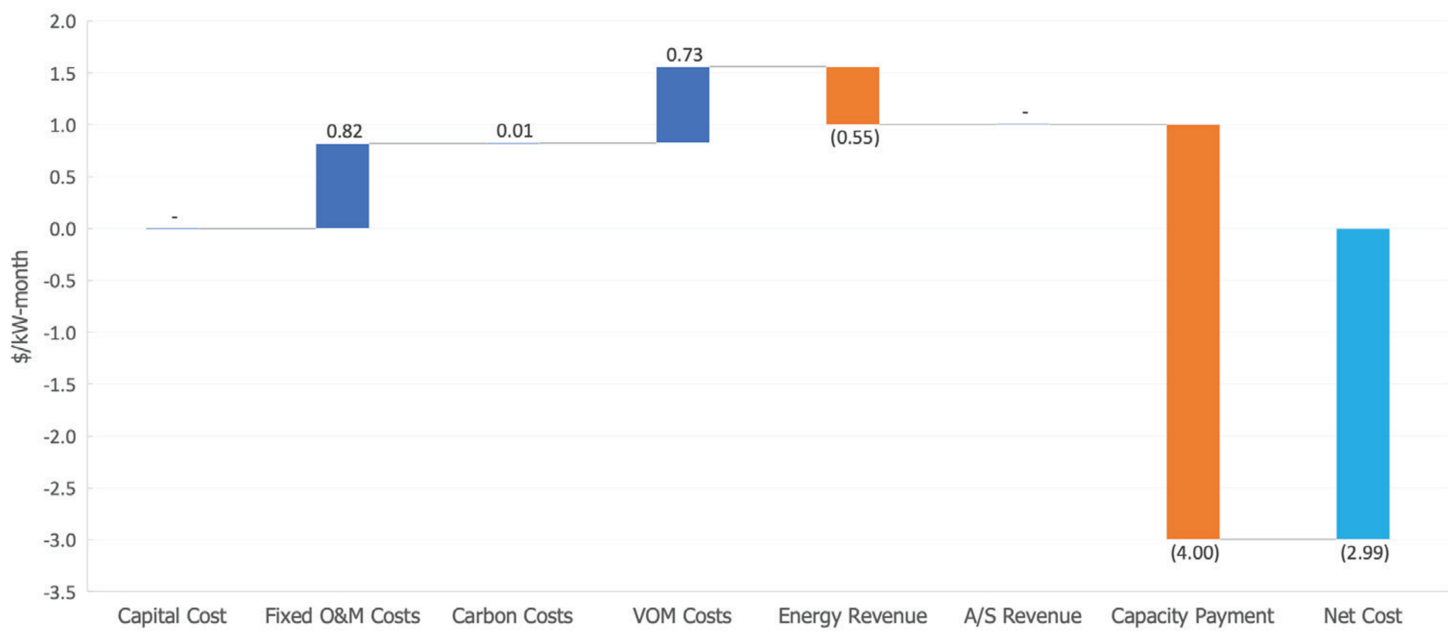
Source: Strategen Consulting

Figure A-2
Bucksport (Verso Paper CT) Net Cost Analysis (QC)



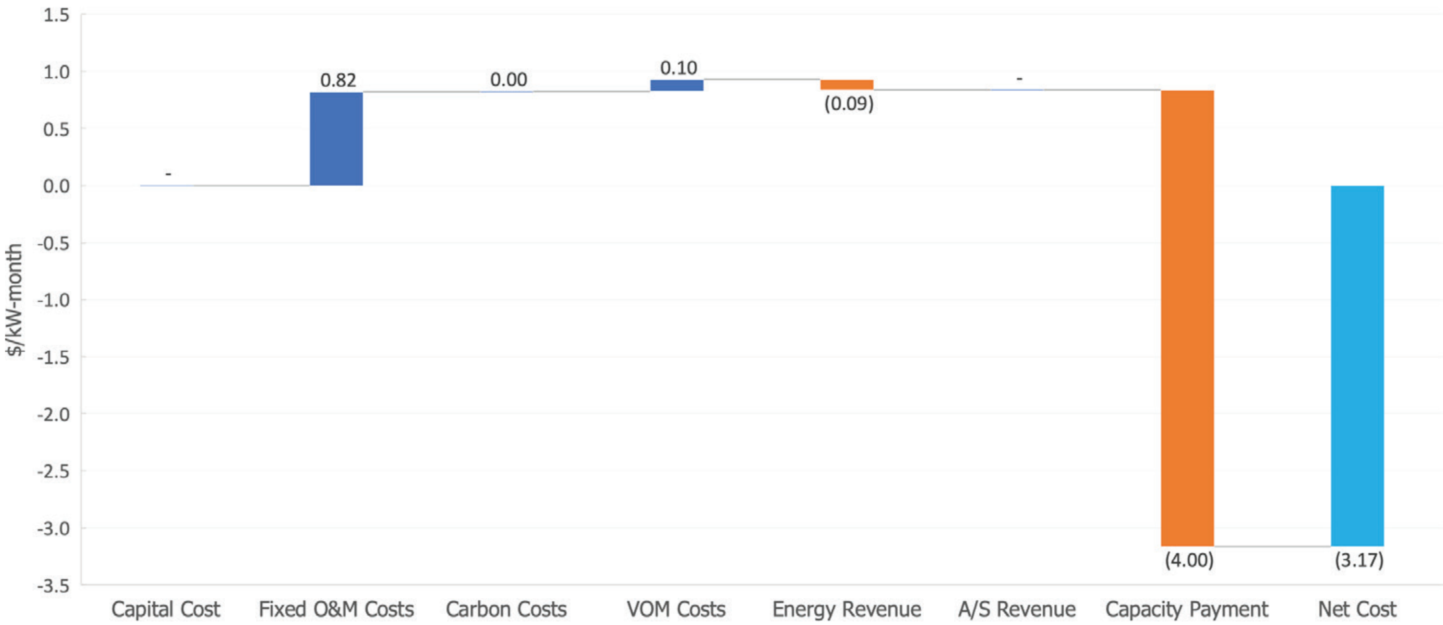
Source: Strategen Consulting

Figure A-3
William F. Wyman Unit 3 Net Cost Analysis (QC)



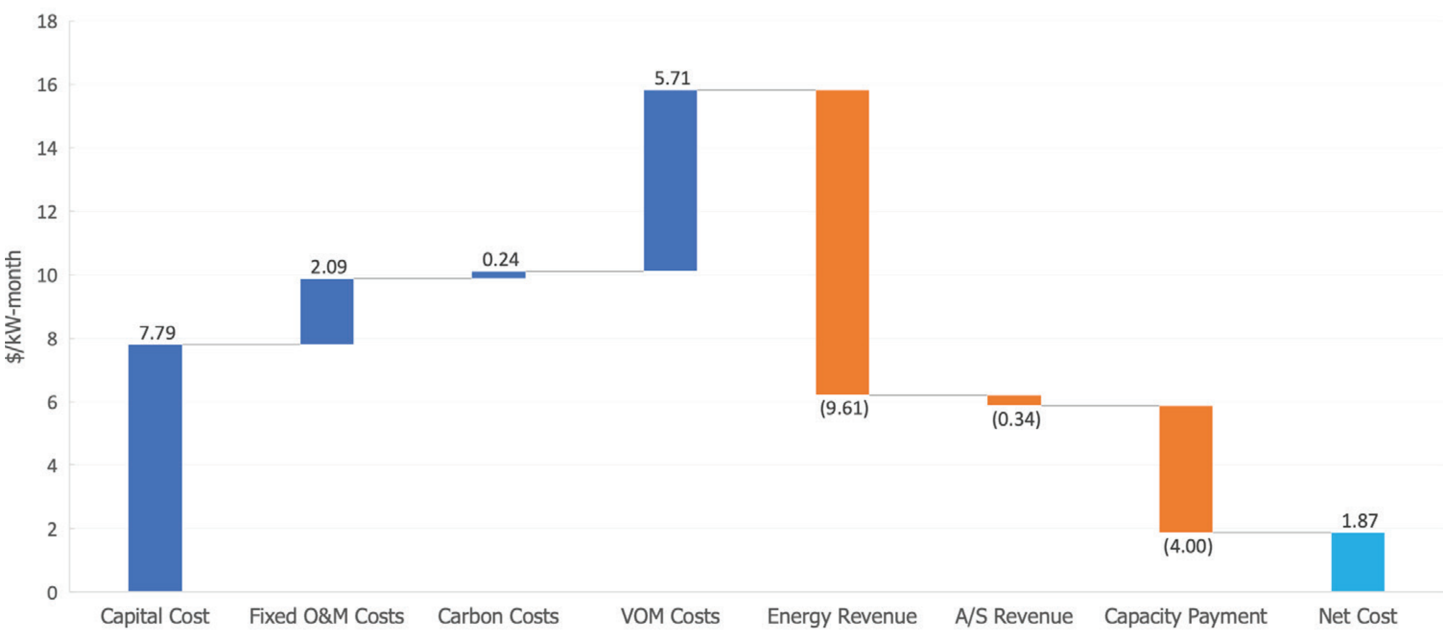
Source: Strategen Consulting

Figure A-4
William F. Wyman Unit 4 (QC)



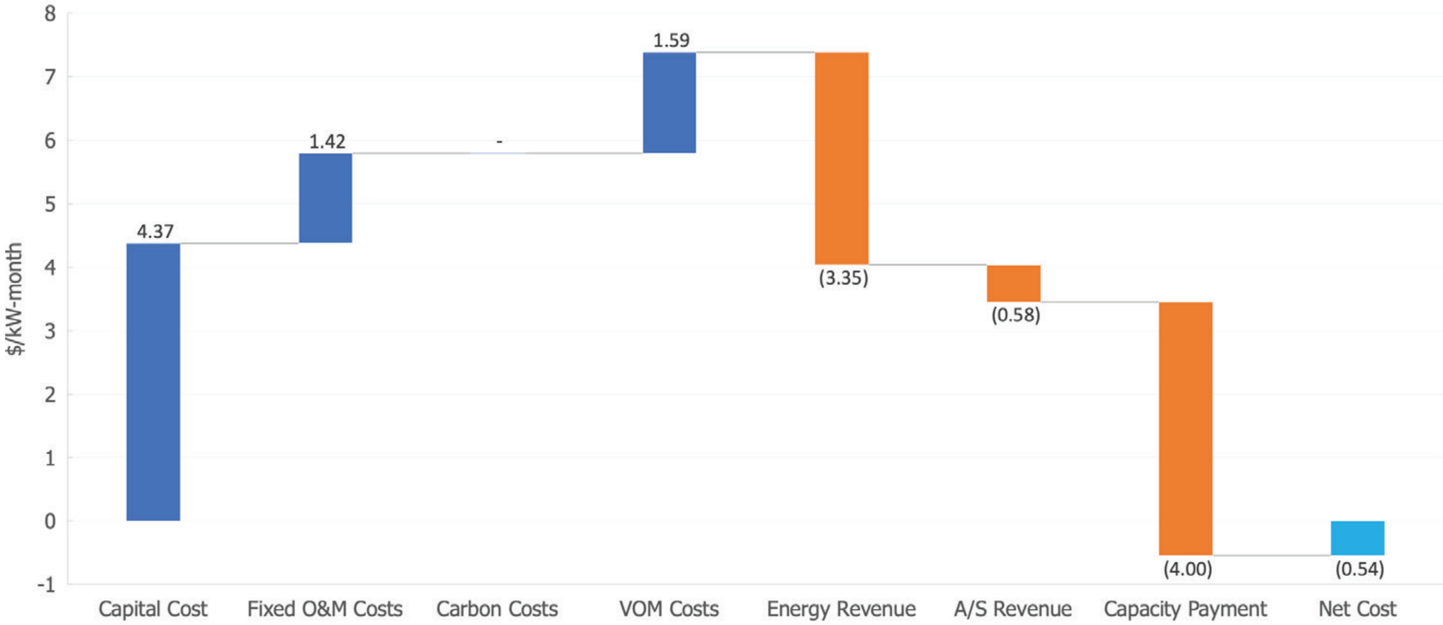
Source: Strategen Consulting

Figure A-5
New F-Frame Peaker Net Cost Analysis (QC)



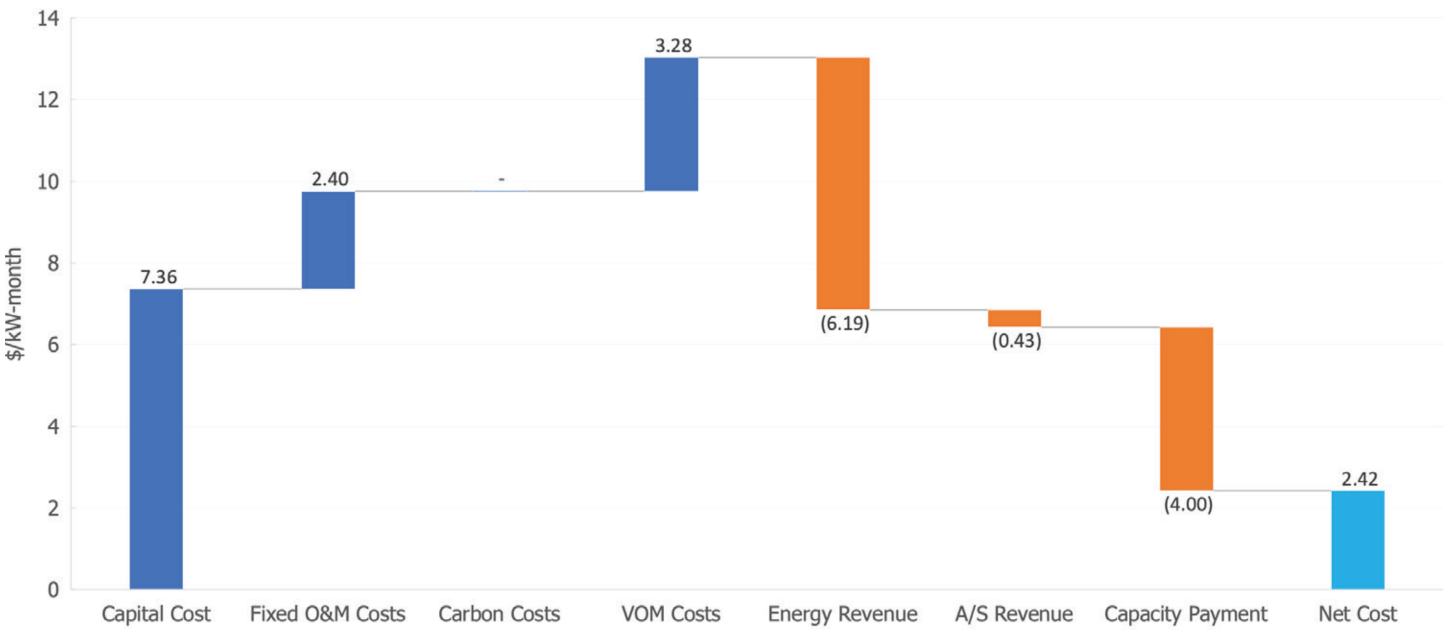
Source: Strategen Consulting

Figure A-6
2-hour BESS Net Cost Analysis (QC)



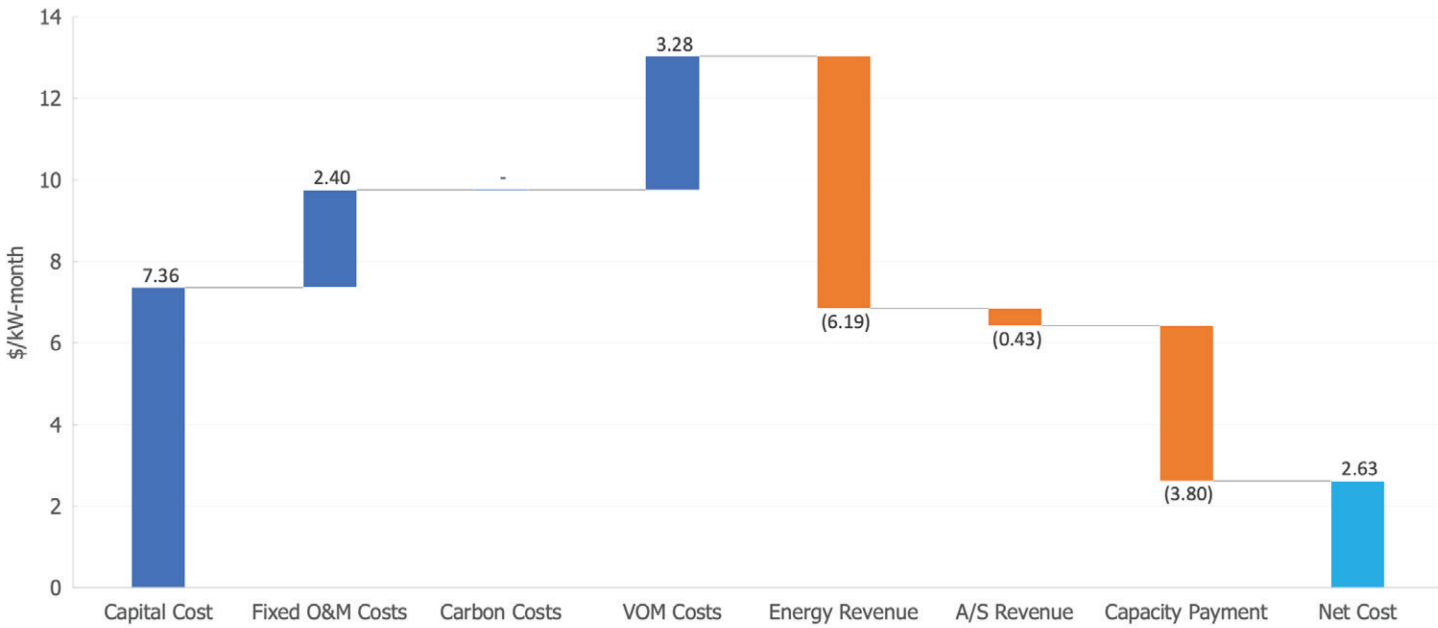
Source: Strategen Consulting

Figure A-7
4-hour BESS Net Cost Analysis (QC)



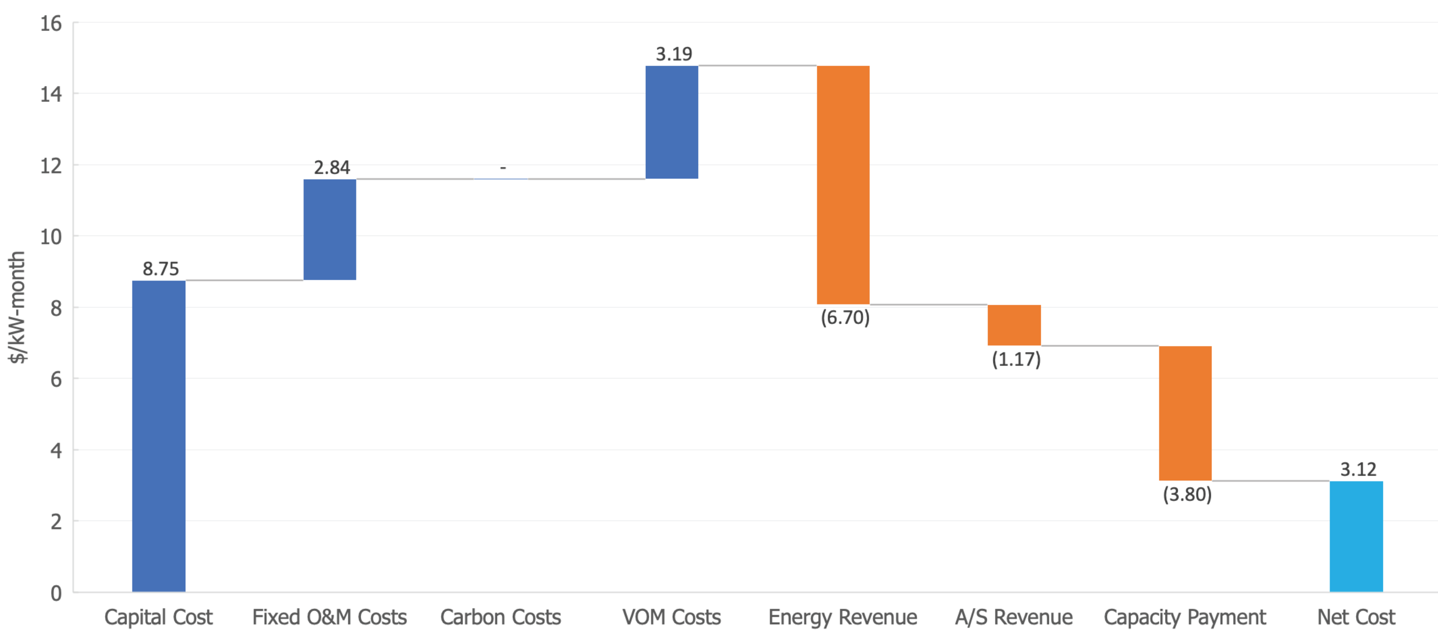
Source: Strategen Consulting

Figure A-8
4-hour BESS Net Cost Analysis (ELCC)



Source: Strategen Consulting

Figure A-9
2-hour BESS Net Cost Analysis (ELCC)

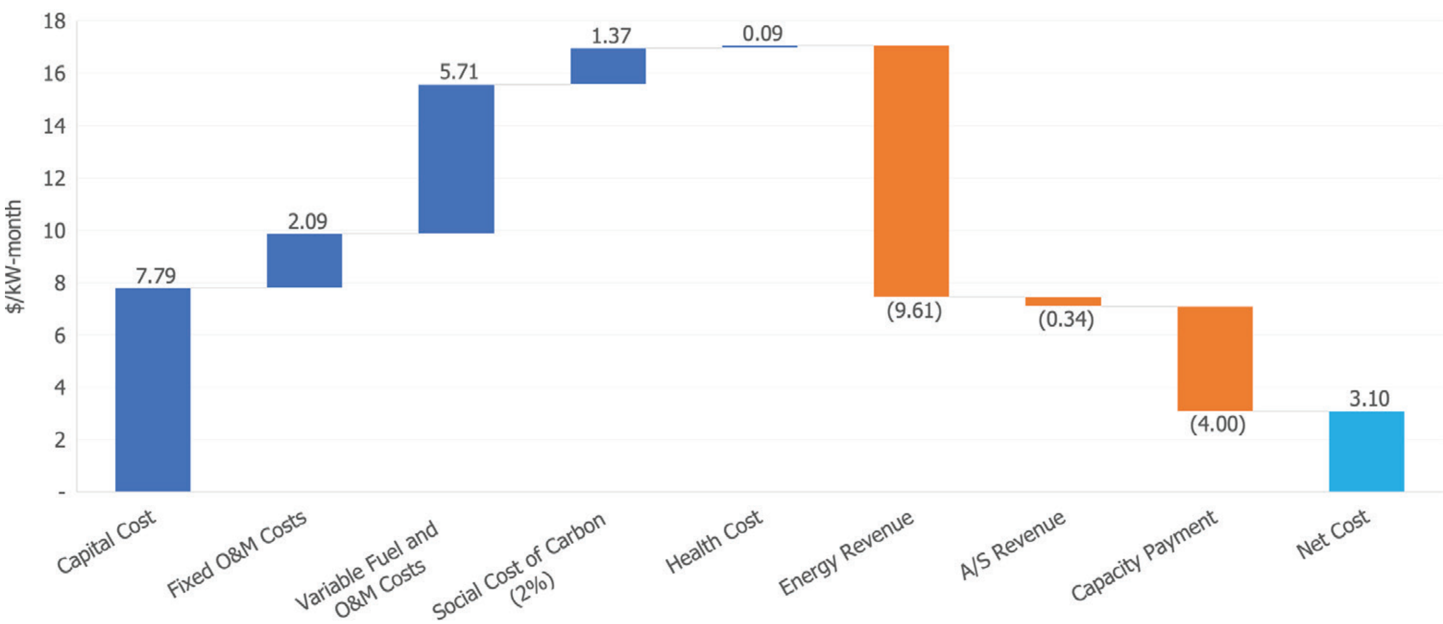


Source: Strategen Consulting

APPENDIX B
Net Cost Analysis Results Inclusive of Health and Societal Costs

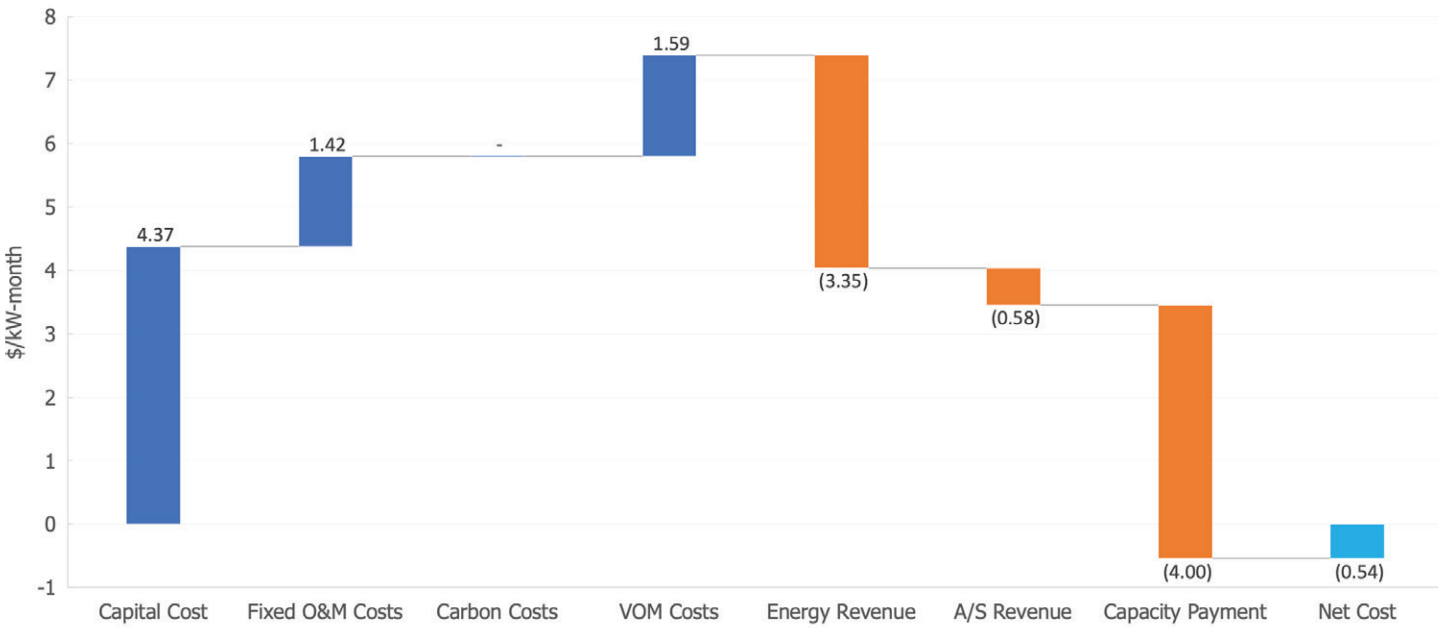
Appendix B shows the net costs of the incumbent (soon to retire) fossil-fueled peakers, compared to the net costs of replacement technologies, under both the current (QC) and presumed future (ELCC) capacity market rules. These results DO consider the costs associated with environmental and human health damage from fossil-fuel air emissions.

Figure B-1
New F-Frame Peaker Net Cost Analysis Inclusive of Health and Societal Costs (QC)



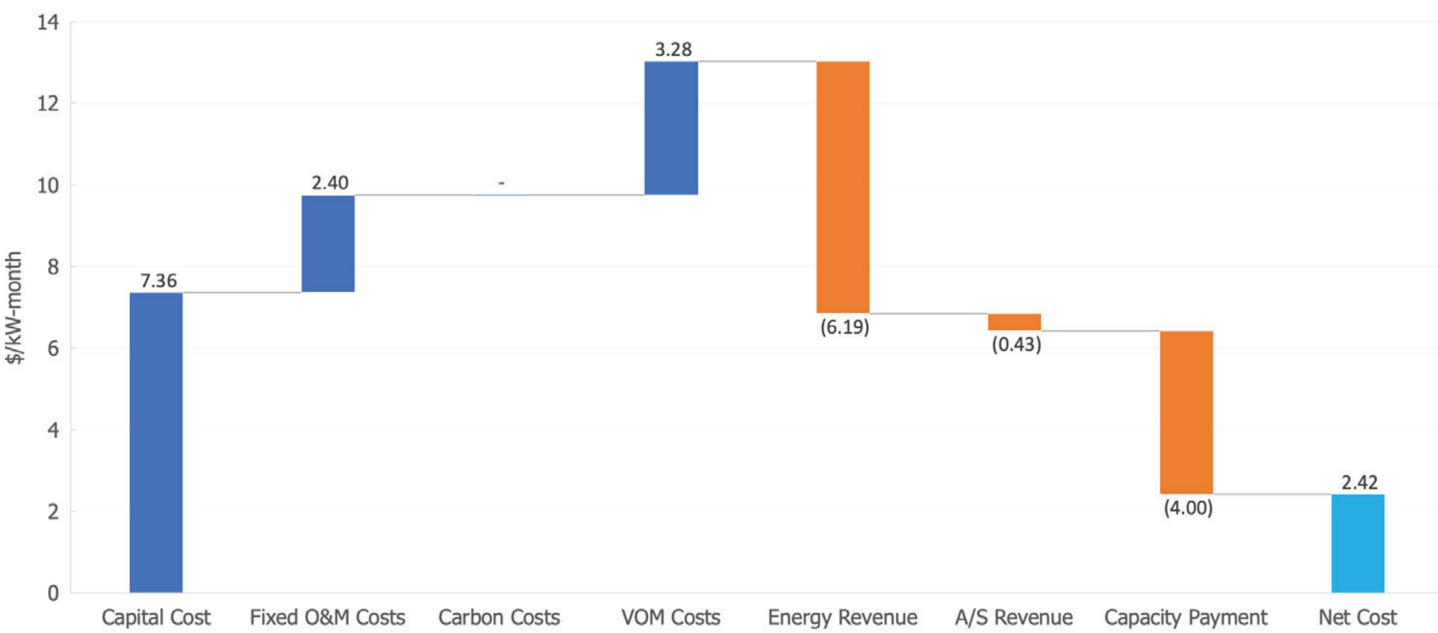
Source: Strategen Consulting

Figure B-2
2-hour BESS Net Cost Analysis (QC)



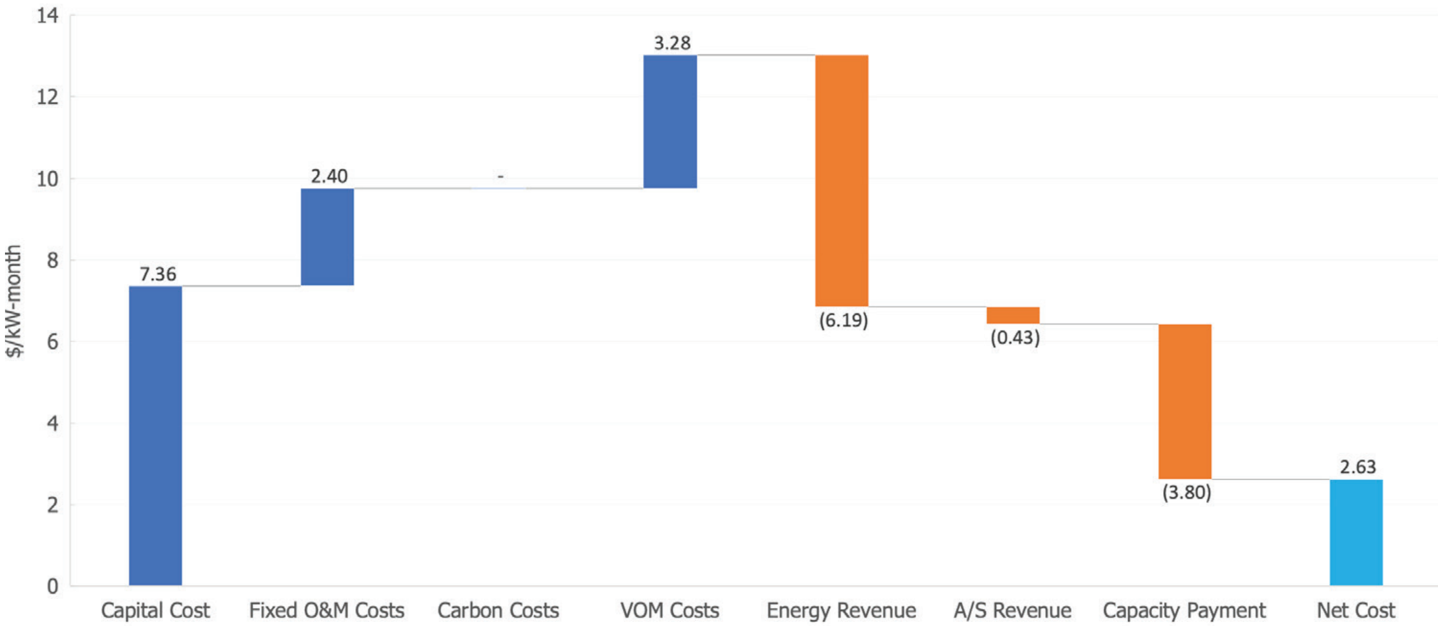
Source: Strategen Consulting

Figure B-3
4-hour BESS Net Cost Analysis (QC)



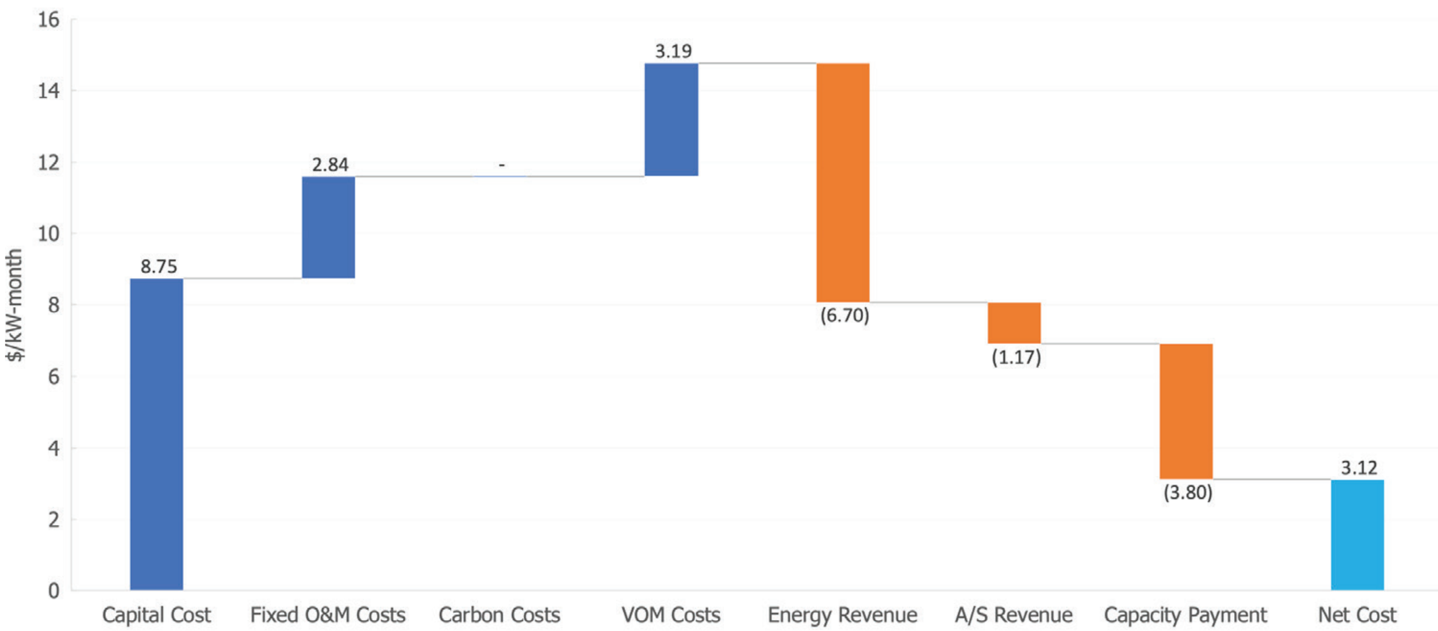
Source: Strategen Consulting

Figure B-4
4-hour BESS Net Cost Analysis (ELCC)



Source: Strategen Consulting

Figure B-5
2-hour BESS Net Cost Analysis (ELCC)



Source: Strategen Consulting

APPENDIX C

Net Cost Analysis Results, Higher BESS Cost Scenario

Appendix C shows an alternate set of net cost analyses that assume a higher BESS cost scenario in the future. This scenario is considered less likely to occur.

Table C-1

Summary of Net Cost Results Under a Higher BESS Cost Scenario, QC and ELCC Cases ($/kW-month), Exclusive of Societal Costs of Air Emissions

QC		ELCC	
Asset	**Net Cost**	**Asset**	**Net Cost**
BESS, 2-hr	0.98	**New F-Frame**	1.87
New F-Frame	1.87	**BESS, 4-hr**	5.06
BESS, 4-hr	4.85	**BESS, 2-hr**	6.16

Source: Strategen Consulting

Table C-2

Comparison of New Peaking Alternatives' Net Costs Under a Higher BESS Cost Scenario, QC and ELCC Cases ($/kW-month), Inclusive of Societal Costs of Air Emissions

QC		ELCC	
Asset	**Net Cost**	**Asset**	**Net Cost**
BESS, 2-hr	0.98	**New F-Frame**	3.10
New F-Frame	3.10	**BESS, 4-hr**	5.06
BESS, 4-hr	4.85	**BESS, 2-hr**	6.16

Source: Strategen Consulting

The Clean Energy States Alliance (CESA) is a national, nonprofit coalition of public agencies and organizations working together to advance clean energy. CESA members—mostly state agencies—include many of the most innovative, successful, and influential public funders of clean energy initiatives in the country.

CESA works with state leaders, federal agencies, and other stakeholders to develop and promote clean energy programs and markets, with an emphasis on renewable energy, energy equity, financing strategies, and economic development. CESA facilitates information sharing, provides technical assistance, coordinates multi-state collaborative projects, and communicates the views and achievements of its members.

Ørsted US Offshore Wind/Block Island Wind Farm

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Clockwise from upper left: Shutterstock/Soonthorn Wongsaita; Tom Piorkowski; Resonant Energy; Portland General Electric; RE-volv; Bigstockphoto.com/Davidm199