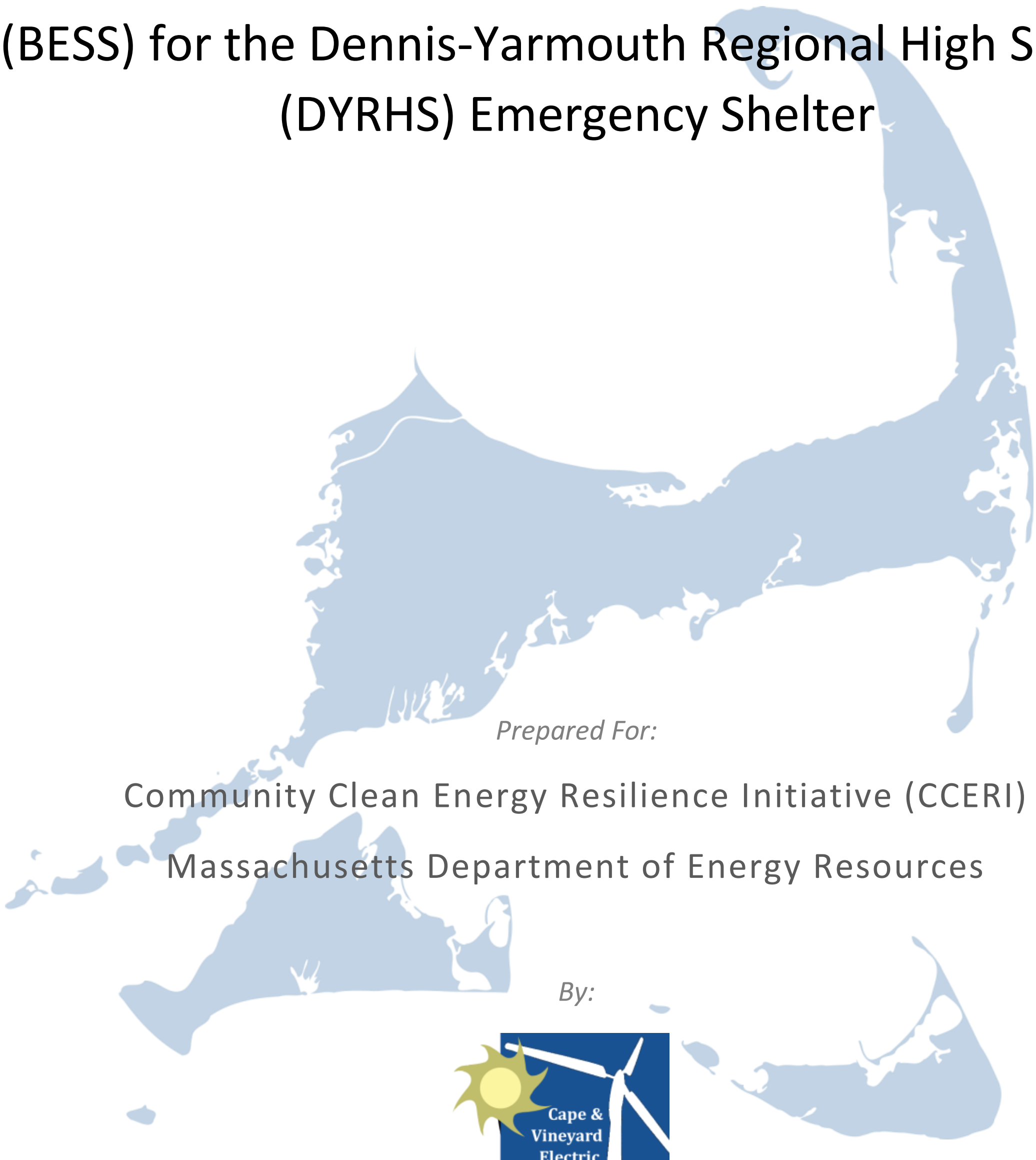
DYRHS BESS Feasibility Study

Feasibility Study based on a Financial Analysis of the Proposed Resilience Battery Energy Storage System (BESS) for the Dennis-Yarmouth Regional High School (DYRHS) Emergency Shelter



Prepared For:

Community Clean Energy Resilience Initiative (CCERI)

Massachusetts Department of Energy Resources

By:

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Overview

The Community Clean Energy Resilience Initiative Grant

Predicted climate change impacts – in particular, sea level rise and more frequent extreme storm events – have the potential to impair public and private services and business operations across the Commonwealth of Massachusetts. Preparing for these future impacts will take a coordinated effort of private and public sectors, non-profit organizations, and managers and users of infrastructure resources. To increase energy infrastructure resiliency and reliability will also require investment in new technologies. Realizing this, in 2013 Massachusetts Governor-elect Deval Patrick announced a multi-dimensional strategy to help Massachusetts prepare for climate change and the increasing incidence of severe weather.

As part of the Patrick Administration's Climate Change Preparedness Initiatives, the Governor directed the Department of Energy Resources (DOER) to administer a $40 million grant program to ensure energy resiliency at critical facilities in municipalities using clean energy technology. As such, DOER's "Community Clean Energy Resiliency Initiative" (CCERI) recognized that climate change-induced events impact our entire Commonwealth and that municipalities and other public entities are at the forefront of responding when such events occur.

For the CCERI grant, DOER defined critical facilities as buildings or structures where loss of electrical service would result in disruption of a critical public safety life sustaining function. DOER prioritized these critical facilities and provided examples of critical facilities, as follows:

1. Life safety resources, e.g. police, fire, hospitals, wastewater treatment plants, emergency communication resources and shelters
2. Lifelines resources, e.g. food and fuel supply, and transportation facilities and resources
3. Community resources, e.g. city/town halls, senior centers, schools and/or multifamily housing developments capable of acting as alternative shelters

In keeping with the DOER's prioritization of improving municipal resilience, the Cape & Vineyard Electric Cooperative, Inc (CVEC) applied for a CCERI Technical Assistance grant to provide a feasibility review of a potential battery energy storage system (BESS) for the Dennis-Yarmouth Regional High School (DYRHS) Emergency Shelter. CVEC had previously installed a 590-kilowatt photovoltaic (PV) system at DYRHS, and, as a critical community resource which serves as an emergency shelter (i.e. life safety resource), the facility presented a prime opportunity for a CCERI grant.

About the Cape and Vineyard Electric Cooperative

Following a strategic planning process undertaken by the Cape Light Compact (CLC), a Massachusetts Joint Powers Entity providing regional power and energy efficiency programs, the Cape and Vineyard Electric Cooperative (CVEC) was organized in 2007. CVEC's mission is to provide the municipalities of the Massachusetts South Coast, Nantucket and Martha's Vineyard a way to work together to integrate clean, renewable energy as a part of a more sustainable region. CVEC's work has resulted in the installation of over 30 megawatts (MW) of solar photovoltaics on capped landfills and roofs, with an additional 8 MW of power purchased from off-Cape renewable energy installations.

About the Dennis-Yarmouth Regional High School Emergency Shelter

In 2009 the Dennis-Yarmouth Regional High School (DYRHS) was designated a Regional Shelter by the Barnstable County Regional Emergency Planning Committee (BCREPC). The DY High School is the appointed shelter to serve the Mid-Cape, a particularly densely populated region at the center of the Cape's commercial areas. The facility is one of six regional shelters open to all residents and visitors (and accompanying pets) of Barnstable County during a natural or man-made disaster. In addition, due to the size and capacity of the facility, DYRHS serves as a food preparation and distribution unit for the remaining shelters (in conjunction with food and beverage provided by the American Red Cross).

In July 2014, following the CCERI application, CVEC was awarded a DOER CCERI Technical Assistance grant. Utilizing the grant, a technical proposal was developed by the Cadmus Group to establish that a BESS, in conjunction with the 590-kilowatt photovoltaic (PV) system CVEC had previously installed at this location, would extend the emergency facility's functionality during extended grid outages. The technical proposal also identified basic parameters, recommending battery size and power duration.

Based on these findings, CVEC then applied for the CCERI Implementation grant, which was awarded by DOER in the amount of $1,479,193 in December 2014.

However, prior to fulfilling the CCERI Implementation grant and initiating construction processes, it was critical for CVEC to verify the feasibility of a potential battery project's finances. With a 10% match requirement as part of the Implementation grant terms, CVEC needed to establish a revenue stream from the battery equal to the potential match of up to $147,919. For this reason, the CVEC CCERI grant contract was written to include an initial milestone, Phase 1, calling for the selection of specific battery technology and system design, and, based on those selections, calling for the completion of a financial analysis to illustrate the feasibility of the project.

The following "DYRHS BESS Feasibility Study" fulfills Phase 1 of the CCERI Implementation grant, by verifying the feasibility of the BESS at DY High and the financial merits of the project when entering the competitively selected vendor's chosen technology and system design into current energy markets.

Request for Proposal Development

As noted, because the financial analysis of the proposed DYRHS BESS was dependent on the technical parameters of the BESS, the first task for CVEC was the selection of a qualified vendor to establish the BESS technology and design. Towards that end, CVEC worked from 2015-2017 to design one of the nation's first Request for Proposals (RFP) for a BESS at the DYRHS Emergency Shelter.

To prepare for the authoring of the RFP, CVEC interviewed manufacturers, developers, and engineers including the vendors Bright Power, GreenCharge, and VizN. The extensive interviews helped CVEC gain an understanding of emerging battery technologies, paths to proper sizing, quantification of emerging and existing markets for controlled disbursement of the battery power, effects of cycling on battery life spans, and mitigation of environmental concerns. The interviews also provided CVEC with potential system pricing information. Prices ranged significantly, with the most conservative estimates costing more than twice the lowest cost estimates. This range was attributed to 1) different battery technologies, 2) having received pricing information at different times, 3) estimators' varying levels of understanding of the specifics of the site, and 4) pricing variations specific to the different vendors.

In 2016 CVEC's RFP efforts were further augmented by expert guidance from Clean Energy States Alliance (CESA). Through a grant from the Barr Foundation, CESA's Todd Olinsky-Paul played a key role as the lengthy and complex process of developing an essentially heretofore non-existent Battery System RFP progressed. CESA, in turn, provided access to Sandia National Laboratory, with Sandia's Dan Borneo also contributing to the RFP development. In addition to key technical considerations, Sandia provided a preliminary Revenue Report identifying potential markets for BESS participation.[1]

To inform technical requirements for the RFP based on the existing DYRHS electrical system, and to serve as CVEC's Owner's Agent should the BESS project go forward into implementation, CVEC hired consultant Scott Reynolds of Reynolds Engineering in 2016. Mr. Reynolds had previously served as Owner's Agent on a similar CCERI grant battery project installed for a municipal light plant in Sterling, Massachusetts.

Recognizing the importance of input from local authorities, CVEC held multiple meetings with the Town of Yarmouth's first responders and planning agents. The consensus from these meetings was that the added resilience for the DYRHS Emergency Shelter from the proposed BESS was desirable, and that the battery system should be housed in a separate building adjacent to the school.

CVEC held an initial discussion regarding the interconnection of the BESS with the local utility, Eversource. Eversource Distributed Generation Account Executive Brett Jacobson informed CVEC that any substantial interconnection questions could only be answered following an engineering review triggered by a Distributed Generation application and Work Order request. These could not be submitted without any technical parameters determined by a selected developer. Therefore, any limitations or dictates from the local utility were unavailable for inclusion in the RFP's parameters.

As the BESS RFP neared completion in 2017, a key issue remaining was the determination of the proper procurement law to guide the solicitation, e.g. MGL 30B, 25A or 149. Inquiry into the matter involved CVEC counsel, Kevin Batt (of Anderson Kreiger), DOER, the Massachusetts Attorney General's office, and the Massachusetts Inspector General's office. In July of 2018, DOER communicated to CVEC that 30B was the proper procurement law under the CCERI grant requirements.

Proposal Solicitation Critical Parameters

Based on the Cadmus Technical Study of 2014, vendor interactions prior to the RFP release, and in consultation with CVEC's Owner's Agent and the CESA consultant, CVEC determined that the most readily available and affordable battery technology for the DY BESS project would be lithium ion. This was the first parameter for the RFP.

The second RFP parameter was dictated by the resilience requirement of the grant: an overall 3-day extension to current (fossil fuel based) resilience during grid outages. Again, the Cadmus study, vendor recommendations, and CVEC's consultants all pointed to a minimum battery size of 250kW with a 4-hour capacity (i.e., 1000 kWh). This was the second parameter for the RFP.

[1] See Supplementary Information for Sandia Revenue Report.

The third parameter was that CVEC would own the battery system outright. This was also dictated by the state CCERI grant requirements.

A fourth parameter was housing the battery system in a separate building next to the school building, as identified in interactions with the town.

While these four parameters were foremost in the RFP, proposers were encouraged to think creatively, with the RFP stating that CVEC sought an optimal system with minimum risk and maximum revenue. For example, because CVEC had learned that the single largest driver of revenue and financial benefits would be the size of the system, the vendors were invited to propose systems larger than the required minimum of 1000kWh, as long as the system remained within the budget constraint of under $1,470,000.

To further facilitate creativity and variation, respondents were encouraged to submit up to two separate proposals with alternate system designs and/or contracting structures.

To aid CVEC in the review of proposals, the RFP required that a feasibility analysis be provided based on each system design and ability to engage in emerging battery energy markets.

With these parameters in place, the DYRHS Emergency Shelter BESS RFP was released on August 15, 2018.

Responses

The release of the RFP resulted in three developer's responses:

- Northern Reliability
- Ameresco in partnership with NEC Energy Solutions
- One-Way Construction in partnership with Schneider Electric

The vendors' proposals included only one solution each, 250kW with a 4-hour capacity (i.e., 1000 kWh), and all bids came close to the budget limit of $1,470,000.

Multiple in-person interviews were conducted with One-Way and Ameresco, and follow-up clarifications and supporting material were received. The proposal with Northern Reliability was not considered further, as it did not provide the required feasibility analysis. In April 2019, Ameresco was selected as the preferred vendor due to the proposal's quality, thoroughness, adherence to requests, and lower overall costs, as well as the vendor's qualifications.

Selected Vendor Design Specifications

The Dennis-Yarmouth High School BESS design from Ameresco preserves the current 590kW photovoltaic system (PV) interconnection configuration, with the PV not interconnected to the school, but rather interconnected as Front of the Meter (i.e. the PV power feeds the grid directly)[2]. The BESS will

[2] After an analysis demonstrated that the DY High School's highest kilowatt demand was incurred in early mornings when the proposed 590kW roof-mounted photovoltaic would still be inactive due to low insolation, the proposed PV installation was interconnected in Front of the Meter. The virtual Net Metering Credits earned by the solar production were then allocated to the High School's electric account, effectively eliminating the monthly demand charge along with the overall monthly electric bill reduction.

be added mid-stream, with half of the PV (295kW) feeding the BESS before feeding the grid. The other half of the PV will be routed directly to the grid.

In a resilience event, a manual switch will be activated to shift the BESS and the PV into islanded mode, with the battery and all the PV power flowing to the school. The grid will be cut off from the BESS, PV, and the school. As required, the battery design from Ameresco calls for 250kW and 4 hours of power to ensure adequate resilience.

Feasibility & Financial Analysis

With the technology and the design specifications determined by the selection of Ameresco, the next three steps to establish the financial feasibility of the project were: 1) verification of the revenue stream based on available markets for battery power and Ameresco's selected technology and performance assumptions, 2) determination of CVEC's total BESS costs and, 3) projection of CVEC's annualized costs against the verified annual revenue stream.

Step 1) Verified Revenue Stream

To establish a conservative and verified revenue stream from existing markets for the BESS designed by Ameresco, CVEC turned to multiple experts including CPower, the Demand Response provider for the Commonwealth of MA under a DCAMM contract, and to the Cape Light Compact, the region's power supplier and energy efficiency program administrator. See Appendix 5: Involved Parties for other contributors.

As CVEC began the financial review in spring 2019, multiple battery power markets were still under development, necessitating their exclusion from revenue estimates. For example, while a "Connected Solutions" program for Targeted Dispatch was approved in early 2020 by Massachusetts regulators, a Daily Dispatch program still awaits approval for implementation. Thus, CVEC's review assumes only revenue from the Targeted Dispatch program is available, rather than the potentially more rewarding Daily Dispatch program revenue.

In addition, CVEC's review cannot include the Clean Energy Peak Standard and accompanying certificate program as they are still under development.

The following chart utilizes available programs with established revenue streams to analyze the potential BESS revenue within the Ameresco design parameters.

Year[3]	Assumptions				Preliminary Calculations				Calculated Program Benefits			Total
	BESS Capacity (kW)	Energy Available (kWh) [4]	FCM Clearing Price[5]	CLC DR[6]	ADCR [7] Summer	ADCR Winter	ADCR Sum	CLC DR	Net ADCR[8]	Net CLC DR[9]	Cap Tag[10]	
1	250	900	6.21	$125	$13,414	$6,707	$20,120	$31,250	$14,487	$22,500	$0.00	$36,987
2	250	896	5.50	$125	$11,880	$5,940	$17,820	$31,250	$12,830	$22,500	$10,901	$46,231
3	250	887	4.20	$125	$9,072	$4,536	$13,608	$31,250	$9,798	$22,500	$8,324	$40,622
4	250	882	3.80	$125	$8,208	$4,104	$12,312	$31,250	$8,865	$22,500	$7,532	$38,896
5	250	869	2.00	$125	$4,320	$2,160	$6,480	$31,250	$4,666	$22,500	$3,964	$31,130
6	250	860	2.00	$63	$4,320	$2,160	$6,480	$15,625	$4,666	$11,250	$3,964	$19,880
7	250	855	2.00	$63	$4,320	$2,160	$6,480	$15,625	$4,666	$11,250	$3,964	$19,880
8	250	846	2.00	$63	$4,320	$2,160	$6,480	$15,625	$4,666	$11,250	$3,964	$19,880
9	250	842	2.00	$63	$4,320	$2,160	$6,480	$15,625	$4,666	$11,250	$3,964	$19,880
10	250	833	2.00	$63	$4,320	$2,160	$6,480	$15,625	$4,666	$11,250	$3,964	$19,880
											Grand total:	**$293,264**

*For further details on revenue analysis, definitions and assumptions, see Appendix 2: Calculations & Appendix 3: Assumptions

[3] Start June 2020
[4] Initially 1000 kWh (250kW for 4 hours) less 10% held in reserve with estimated degradation applied
[5] Forward Capacity Market clearing price in year 2023 and beyond based on last known Forward Capacity Auction (FCA14) clearing price, decreasing to $2.00 per kW month
[6] Cape Light Compact Targeted Demand Response Reward ($/kW per year)
[7] ISO-NE Active Demand Capacity Resource
[8] Less Aggregator fee of 28%
[9] Less Aggregator fee of 28%
[10] Assumes 50% of Capacity Tag savings retained as part of pass-through agreement

Step 2) CVEC Costs for DYRHS BESS

To determine the feasibility of CVEC implementing the $1,479,000 CCERI grant and authorizing the BESS installation, costs were identified to be projected against the above revenues.

As part of the grant specifications, the grant is available for items as identified below:

> Initial Disbursement: Up to thirty-five thousand dollars and 00/100 ($35,000), shall be disbursed by DOER for the purposes of engineering and feasibility study fees.
>
> Second Disbursement: Up to seventy thousand one hundred and eighty dollars and 00/100 ($70,180), will be disbursed by DOER for the purposes of permitting, legal and insurance, and partial utility interconnection and permitting once all reporting and contingency requirements have been met.
>
> Third Disbursement: Up to forty thousand dollars and 00/100 ($40,000) shall be disbursed by DOER for the remaining interconnection costs once all reporting requirements have been met.
>
> Fourth Disbursement: Up to seven hundred forty-five thousand eight hundred and forty-five dollars and 00/100 ($745,845) shall be disbursed by DOER for energy storage equipment, accessory building for safe battery storage, and installation labor costs once all reporting requirements have been met.
>
> Final Disbursement: Up to five hundred eighty-eight thousand one hundred sixty-eight dollars and 00/100 ($588,168) shall be disbursed upon verification by DOER for the purposes of routine maintenance, operational expenses, and after a site visit, a review of detailed invoices for a total Project costs.

With the release of this feasibility study, CVEC assumes that the Initial Disbursement will be expensed and the costs of preparing the study (less the 10% match of $3,500) reimbursed, thus, reducing the grant balance to $1,440,693, leaving a $140,919 grant match for CVEC.

A bank loan will be required to meet the remaining $140,919 grant match. CVEC has established the availability of a loan at 4% interest for 10 years for this purpose.

The following chart incorporates the cost of the grant match and associated loan interest payments, the annual fees to Ameresco to ensure professional support, and the cost of a lease payment to compensate the Dennis-Yarmouth School District for the pass-through of Capacity Tag Savings.

Itemized Annualized Expenses

Year Starting	General Professional Support from Ameresco	Lease Payment to DYRHS	Loan Payment*	BESS Decommissioning and Site Restoration Cost	Annual Expenses	Cumulative Expenses
6/1/2020	$5,000	$1,000	$17,121		$23,121	$23,121
6/1/2021	$5,000	$1,000	$17,121		$23,121	$46,242
6/1/2022	$5,000	$1,000	$17,121		$23,121	$69,363
6/1/2023	$5,000	$1,000	$17,121		$23,121	$92,483
6/1/2024	$5,000	$1,000	$17,121		$23,121	$115,604
6/1/2025	$5,000	$1,000	$17,121		$23,121	$138,725
6/1/2026	$5,000	$1,000	$17,121		$23,121	$161,846
6/1/2027	$5,000	$1,000	$17,121		$23,121	$184,967
6/1/2028	$5,000	$1,000	$17,121		$23,121	$208,088
6/1/2029	$5,000	$1,000	$17,121		$23,121	$231,209
6/1/2030				$20,000	$20,000	$251,209

* Annualized bank payment on $140,919 Loan for 10 years @ 4%. Annual Bank Loan Payment includes pay down of principle plus interest.

Step 3) Projection of Annualized Costs Against Annual Revenue Stream

Finally, the annualized costs are compared against revenues to determine the financial feasibility of implementing the BESS project. As is evident in the chart below, the running total of annual revenue exceeds annual expenses. In 2020, when the BESS will be potentially disassembled and the site restored at a cost of $20,000, a $42,054 balance remains. Thus, the financials support the feasibility of the BESS.

Year Starting	Annual Revenue	Annualized Expenses	Balance	Running Total
6/1/2020	$36,987	($23,121)	$13,866	$13,866
6/1/2021	$46,231	($23,121)	$23,110	$36,976
6/1/2022	$40,622	($23,121)	$17,501	$54,477
6/1/2023	$38,896	($23,121)	$15,775	$70,252
6/1/2024	$31,130	($23,121)	$8,009	$78,261
6/1/2025	$19,880	($23,121)	($3,241)	$75,019
6/1/2026	$19,880	($23,121)	($3,241)	$71,778
6/1/2027	$19,880	($23,121)	($3,241)	$68,536
6/1/2028	$19,880	($23,121)	($3,241)	$65,295
6/1/2029	$19,880	($23,121)	($3,241)	$62,054
6/1/2030		($20,000)	($20,000)	$42,054

Conclusion

Building on the Technical Study performed by Cadmus Group in 2014, wherein it was demonstrated that a BESS at the DY Regional High School Emergency Shelter would extend the critical functions of the emergency shelter during extensive grid outages, CVEC has performed a financial analysis that demonstrates the winning developer's specific battery technology's ability to participate effectively in recently emerged and verified battery energy markets. The financial analysis verifies the existence of an adequate and dependable revenue stream from existing battery energy markets to support the implementation of the CCERI grant and development of the DY High School Emergency Shelter BESS project based on known costs.

While CVEC has constructed a positive financial outlook using all known and verifiable costs and incomes, there remains a critical unknown financial consideration, that of potential infrastructure upgrade costs imposed by the local utility, Eversource.

Disclaimer

Appendices

Appendix 1: Index of Terms

ADCR: Active Demand Capacity Resource – a power resource that is accepted into the ISO-NE (Independent System Operators of New England) Forward Capacity Market.

CapTag: Capacity Tag – a fee that energy providers pay based on load. Reduced load reduces energy providers' CapTag payment. For Municipal Light Plants, like the Sterling Municipal Light plant (a CCERI grant awardee), CapTag Savings prove to be a key financial driver. In the DY BESS scenario, the CapTag savings are less impactful, as the CapTag savings are discounted by the High School's energy provider, NextEra.

DR: Demand Response – Power made available locally to relieve negative grid impacts for power providers, like the local utility, when demand is high. The "Connected Solutions" program is in direct response to the need for this market and its reward.

FCM: Forward Capacity Market – provided by the ISO-NE to meet future regional power needs. Power resources (like ADCR) are rewarded for bidding their reliable power into the three-year forward looking Forward Capacity Market Auction.

Gross Up: ISO-NE grosses up the facility's actual kW reduction by 8% to account for Transmission & Delivery line losses.

Appendix 2: Calculations

ISO-NE ADCR

Battery Capacity (Inverter) kW * FCM Price ($/kW month) * 12 months * Gross up * Revenue Share

CLC DR

Battery Capacity (Inverter) kW * CLC DR Price ($/kW year) * Revenue Share

Cap Tag Savings

FCM Price ($/kW month) * 12 months * CapTag Est kW * Reserve Margin * Savings Retained

Appendix 3: Assumptions

Arbitrage

Calculations do not assume the use of Arbitrage (participating in the day ahead energy market) as a revenue due to the assumed Round Trip efficiency battery losses that would cancel out the arbitrage benefits.

Battery Capacity

A battery size of 250kW with a 4-hour capacity (i.e., 1000 kWh) will meet grant resilience requirements.

Battery Degradation

Battery degradation assumption is an average of 24 and 240 cycle per year degradation curves. Note that 10% of the BESS energy will be held in reserve at all times.

Cap Tag Savings

Cap Tag savings were assumed at 1.4 times ADCR revenue (Reserve Margin), per Ameresco (more conservative than the CPower estimate).

CapTag value estimate of 235.95 kW was based on analysis of 5 minute interval data for DYRHS in July & Aug (2017) as provided by CVEC. Accurate value will only be determined after first year of run with BESS.

Confirmation was received from DYRHS energy supplier (NextERA) that capacity can be / is being unbundled from supply contract. Annual confirmation of arrangement will be required.

Cape Light Compact Demand Response Program

The CLC DR program for Daily Dispatch at $225/kW year (See DPU-Electric 2-8) was not utilized. It is critical to note that the Daily Dispatch revenue will only exist if the CLC gets Massachusetts Department of Public Utilities approval and approval for the tariff amount.

The CLC DR program for Targeted Dispatch at $125/kW year (See DPU-Electric 2-8) was utilized as it has received DPU approval. The assumption is that the CLC DR Targeted Dispatch Program will not drop value after year 5 based on CPower position.

Note that if the BESS is enrolled in CLC Daily Dispatch then it cannot be enrolled as an Active Demand Capacity Resource and would need to be enrolled as an On Peak Hours Resource.

Cycling

The BESS for the DY High School Emergency Shelter will not be subject to specific cycling requirements as is the case for a BESS qualifying in the Solar Massachusetts Renewable Target (SMART) program.

Demand Charge Reduction

Demand Charge Reduction (dispatching the system in a Behind the Meter function to eliminate spikes in the school's kilowatt demand and resulting high utility demand charges) was not assumed. The PV and BESS installations will be Ahead of the Meter in a direct grid feed. Also, Demand Charge Reduction was considered a less impactful revenue stream as the existing solar installation effectively reduces the demand charges through the allocation of virtual net metering credits on the facility's electric bills.

Forward Capacity Market prices

Forward Capacity Market prices were provided by CPower. Prices in year 2023 are based on the latest available data from FCA 14 and decrease to $2.00 per kW month.

Frequency Regulation

Participation in the Frequency Regulation market was not assumed as the market is not particularly robust following regional saturation.

Other

The assumed $141,000 CVEC grant match share following reimbursement less match of 10% for feasibility study (Phase 1 of CCERI grant) is conservative. The grant match could be further reduced by in-kind contributions, etc.

Project Life

A 10-year project life was assumed, although longer battery life is likely.

Revenue Sharing with Aggregator Partners

A 72%/28% revenue sharing of revenue with aggregators was assumed. This is in line with CVEC's current contracts with its aggregators.

Transmission and Distribution Line Losses

Assumes the ISO-NE will gross up facility's actual kW by 8% to account for T&D line losses, which generation does not have to provide.

Appendix 4: Battery Degradation

Provided by Ameresco, hardware vendor
10% reserve
4-hour resilience

Capacity (Inverter / kW)	250
Starting Energy (kWh)	1000
Reserve	10%

Year	Effective Capacity	24 cycles/yr	240 cycles/yr	Average
0	900	100%	100%	100%
1	896	100%	99%	100%
2	887	99%	98%	99%
3	882	99%	97%	98%
4	869	98%	95%	97%
5	860	97%	94%	96%
6	855	97%	93%	95%
7	846	96%	92%	94%
8	842	96%	91%	94%
9	833	95%	90%	93%
10	828	95%	89%	92%
11	819	94%	88%	91%
12	815	94%	87%	91%
13	806	93%	86%	90%
14	801	93%	85%	89%
15	792	92%	84%	88%
16	788	92%	83%	88%
17	779	91%	82%	87%
18	774	91%	81%	86%
19	765	90%	80%	85%
20	761	90%	79%	85%

Appendix 5: Involved Parties

Ameresco • Ed Bludnicki, Senior Project Developer • Jackson Doughty, Project Development Engineer	➢ Renewable energy manufacturer and supplier ➢ Battery specification subject matter expert ➢ Winning CVEC BESS RFP bidder
Cape & Vineyard Electric Cooperative, Inc. (CVEC) • Liz Argo, CVEC Executive Director • Steve Gavin, CVEC Director representing Town of Yarmouth • Sandra Cashen, DY Regional School District Facilities Manager • John Clark, Technical Consultant	➢ CCERI Grant applicant ➢ Governmental entity performing as energy cooperative to benefit regional member governmental entities ➢ Currently manages a portfolio of over 30MW of photovoltaics ➢ On target to install another 24MW with paired storage
Cape Light Compact (CLC) • Stephan Wollenburg, Senior Power Planner • Austin Brandt, Senior Power Planner	➢ Municipal power aggregator ➢ Regional power supplier and energy efficiency manager ➢ CVEC sister organization and founding member ➢ Responsible for both utility Demand Response awards and CapTag recovery for Cape Cod
Clean Energy States Alliance (CESA) • Todd Olinsky-Paul, Project Director	➢ National, nonprofit coalition of public agencies and organizations working together to advance clean energy
CLEAResult • Lisa Barrett, Project Manager, Clean Energy Markets	➢ CLEAResult designs, markets and implements energy programs around the globe
CPower • William Cratty, Senior Technical Sales • Mat Tuttelman, Account Executive - ISONE	➢ Demand-side energy management company ➢ Demand Response provider for state and municipalities ➢ Aggregates for CVEC under DCAMM contract in the ISO-NE On Peak Hours Resources market
National Grid • Stephan Wollenburg, Lead Strategic Business Analyst at National Grid	➢ Massachusetts Electric Utility
Reynolds Engineering|Design LLC • Scott Reynolds, P.E.	➢ Owner's Agent on Sterling BESS project ➢ Owner's Agent on CVEC BESS project
Sandia National Laboratories • Dan Borneo, Engineering Program/Project Lead • Raymond Byrne, Manager, Electric Power System Research Department	➢ National Technology and Engineering Solutions of Sandia operates Sandia National Laboratories as a contractor for the U.S. Department of Energy's National Nuclear Security Administration (NNSA) and supports numerous federal, state, and local government agencies, companies, and organizations. Sandia's energy storage program is funded by the Department of Energy Office of Electricity under the direction of Dr. Imre Gyuk.

Appendix 6: Potential Revenue Sources

In preparing for the release of the RFP and ensuing financial benefit analyses for all proposed systems, CVEC's consultant from the Cape Light Compact from 2015 - 2017, Stephan Wollenburg, prepared the following chart with definitions of market opportunities.

Table 1: Potential revenue sources. Bold text indicates inclusion in financial analysis.

Market/revenue	Source	How it works	Pros	Cons
Demand charge management	Electric bill – distribution savings	Reduce peak monthly demand (highest power draw over the month)	Works with existing billing structure – no need to enroll in new market	Requires deep cycling battery nearly every day; limits flexibility in using BESS for other markets
Capacity tag management	**Electric bill – power supply savings**	**Reduce coincident peak – usage during ISO-NE's peak annual hour**	**Annual savings (significant $) with limited number of cycles**	**Need to predict peak hour; requires compatible power supply contract**
Demand response – capacity	**ISO-NE payment**	**Discharge battery when prompted by ISO-NE in response to scarcity events**	**Significant $ with limited number of cycles**	**Need to participate in aggregation – dilutes $. Unknown duration of scarcity events limits $**
Frequency Regulation	ISO-NE payment	Charge, discharge battery rapidly in response to ISO-NE signal for grid voltage support	Significant $. Well-suited for power (vs. energy) applications	ISO requires 1 MW (can be aggregated). Developing battery market may suppress prices in future, making projections potentially unreliable.
Arbitrage	ISO-NE payment or power supply savings	Buy/charge with inexpensive electricity, sell/discharge expensive	Participation at specific times not required – allows flexibility	Limited $. Requires deep-cycling battery which, depending on technology, will degrade it.

Demand Response

As noted in the chart above, Demand Response (DR) is an ISO-NE program that uses behind-the-meter resources to help reduce load when the New England grid experiences scarcity conditions (generally during summer peaks). Resources bid in a certain number of kW that they must be able to provide for as long as the scarcity condition lasts. Generally, these events only occur a limited number of times a year (less than a dozen in most years), and usually last for less than an hour, but have stretched up to more than four hours. There are penalties associated with not delivering when called on to operate. Some companies, such as CPower, serve as DR aggregators. Such aggregators help tackle the challenging logistics of participating in this program. Furthermore, such aggregators maintain a portfolio of resources. Because a battery can only discharge for so long before needing to recharge, one must limit its power (kW) bid based on its amount of energy (kWh). Discussions with CPower suggest that we should assume a maximum four-hour DR event. Because aggregators have a portfolio of different types of (DR) resources, they can spread risk of a longer event across their entire portfolio.

Revenues are based upon the kW committed for the system and the capacity clearing price, which is established three years in advance. The table below shows projected DR revenues using actual and estimated capacity clearing prices, assuming a bid of 187.5 kW (750 kWh/4 hours). The table assumes that CVEC keeps 72% of the revenue, with the remainder going to the aggregator. Every source we've reviewed include similar savings calculations for demand response revenue, although the system size has varied greatly. This is perhaps the most straightforward source of revenue. Keep in mind, these numbers assume a system size consistent with the most conservative pricing estimates.

Table 2: Projected revenues from Demand Response[11]

	Year	$/kW-month clearing price	Revenue	After revenue share
Actual	2018-2019	$11.97	$26,932.50	$19,391.40
Actual	2019-2020	$7.59	$17,077.50	$12,295.80
Estimated	2020-2021	$6.50	$14,625.00	$10,530.00

Capacity Tag Management

While Demand Response produces revenue by essentially serving as a generation resource in the capacity market, Capacity Tag management would produce savings by reducing the school's financial obligation to the capacity market. The capacity market compensates generators for being available to generate electricity. Consumers of electricity in ISO-NE pay for capacity costs based upon their percent of total New England demand during ISO-NE's peak annual hour. By reducing consumption during this peak hour, a consumer reduces their capacity costs for the entire following year. These capacity costs are rolled into the cost of energy supply. To realize these savings, the battery would be discharged during hours that could be the annual peak. Predicting these hours is a relatively straightforward task, as they occur during the hottest days of the year, and ISO-NE provides load projections a day in advance.

These savings are calculated in almost the exact same way that DR savings are calculated. The only difference is that the price is adjusted for system losses, as one calculation is based upon wholesale supply, while the other is based upon retail demand. See the table below for estimates. Again, most of the information provided to CVEC included savings for capacity tag management.

Table 3: Projected revenues from Capacity Tag Management[11]

	Year	$/kW-month	Revenue	After revenue share
Actual	2018-2019	$11.08	$24,930.00	$17,949.60
Actual	2019-2020	$7.03	$15,817.50	$11,388.60
Estimated	2020-2021	$6.00	$13,500.00	$9,720.00

Note that the current electricity provider contracted by the **Cape Light Compact** for DY Regional School District, **NextEra**, agreed that the Capacity Tag savings could be passed on by them to the account

[11] Results from prior CVEC study. Further values presented in this report were produced by a more recent analysis and are likely to be more accurate.

holder, in this case Dennis-Yarmouth School District. The District is aligned with CVEC in bringing forward the project and will pass the capacity tag savings through to CVEC.

Frequency Regulation

Sandia National Laboratories estimated revenue from Frequency Regulation for the DY High School Emergency Shelter BESS battery project but noted challenges to participating in this market. ISO-NE requires a minimum of 1 MW in order to participate in the frequency regulation market, and while multiple smaller units can be aggregated to meet this requirement, no such aggregation currently exists. For this reason Frequency Regulation was not included as a revenue source for the DY High School Emergency Shelter BESS.

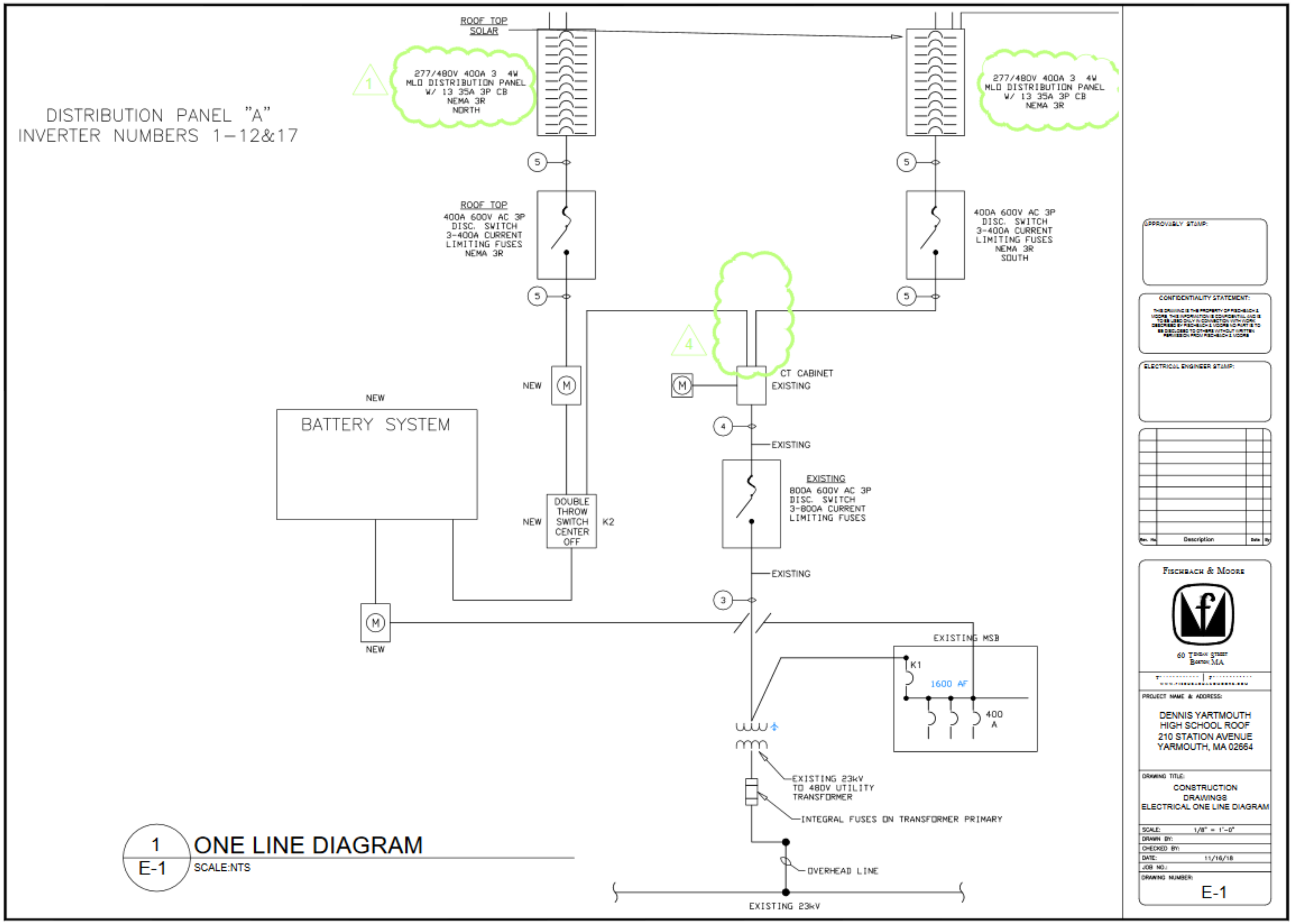
Demand Charge Management

Demand Charge Management is one of the most common sources of savings, but, unlike Demand Response and Capacity Tag management, it requires deep-cycling the battery almost every day. Deep-cycling of the battery is undesirable as it decreases the overall life of the battery.

Arbitrage

Arbitrage has a similar issue with battery deep-cycling requirements, and, based on Sandia National Lab's calculations, is likely to produce even less savings than the less desirable Demand Charge Management described above.

Appendix 7: System Single Line Diagram from Ameresco Specifications



Appendix 8: Interactive Revenue Table

To access this table as an interactive Excel Spreadsheet, please go to http://www.cvecinc.org/wordpress/cvec-bess-at-dy-high-school/ .

	Plug-in Assumptions				Preliminary Calculations				Calculated Program Benefits			
Start June 2020 YEAR	**BESS Capacity in kW**	**Energy Available (in kWh) Starts at 1000 kWh (250kW for 4 hours) less 10% reserve* and applied degradation**	**Assumed Forward Capacity Market (FCM) clearing price for 250 kW**	**Cape Light Compact Demand Response Reward ($/kW per year)**	Forward Capacity Market Active Demand Capacity Resource (ADCR) Reward Summer	Forward Capacity Market Active Demand Capacity Resource (ADCR) Reward Winter	Sum of Summer & Winter ADCR Rewards	Cape Light Compact Demand Res-ponse Reward	**Net Forward Capacity Market Active Demand Capacity Resource Reward (Winter & Summer) - Less Aggregator fee of 28%**	**Net Cape Light Compact Demand Response Reward - Less Aggregator fee of 28%**	**Passed Through Cap Tag Savings (50% of Total)**	**Total**
1	250	900	6.21	$ 125	$ 13,414	$ 6,707	$ 20,120	$31,250	$14,487	$22,500	$0.00	**$36,987**
2	250	896	5.50	$ 125	$ 11,880	$ 5,940	$ 17,820	$31,250	$12,830	$22,500	$10,901	**$46,231**
3	250	887	4.20	$ 125	$ 9,072	$ 4,536	$ 13,608	$31,250	$9,798	$22,500	$8,324	**$40,622**
4	250	882	3.80	$ 125	$ 8,208	$ 4,104	$ 12,312	$31,250	$8,865	$22,500	$7,532	**$38,896**
5	250	869	2.00	$ 125	$ 4,320	$ 2,160	$ 6,480	$31,250	$4,666	$22,500	$3,964	**$31,130**
6	250	860	2.00	$ 63	$ 4,320	$ 2,160	$ 6,480	$15,625	$4,666	$11,250	$3,964	**$19,880**
7	250	855	2.00	$ 63	$ 4,320	$ 2,160	$ 6,480	$15,625	$4,666	$11,250	$3,964	**$19,880**
8	250	846	2.00	$ 63	$ 4,320	$ 2,160	$ 6,480	$15,625	$4,666	$11,250	$3,964	**$19,880**
9	250	842	2.00	$ 63	$ 4,320	$ 2,160	$ 6,480	$15,625	$4,666	$11,250	$3,964	**$19,880**
10	250	833	2.00	$ 63	$ 4,320	$ 2,160	$ 6,480	$15,625	$4,666	$11,250	$3,964	**$19,880**
										Grand total:		**$293,264**
				Aggregator share		72%						
			% Cap Tag Estimate kW			235.95						
		% Cap Tag savings retained				50%						

For further details on revenue analysis, definitions and assumptions, see Appendix 2: Calculations, & Appendix 3: Assumptions