STATE OF NEW HAMPSHIRE

BEFORE THE

NEW HAMPSHIRE PUBLIC UTILITIES COMMISSION

DOCKET NO. DE 19-057

REQUEST FOR PERMANENT RATES

DIRECT TESTIMONY OF

CHARLOTTE B. ANCEL and JENNIFER A. SCHILLING

Grid Transformation and Enablement Program:

Clean Innovation Projects

On behalf of Public Service Company of New Hampshire

d/b/a Eversource Energy

May 28, 2019

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PETITION OF PUBLIC SERVICE COMPANY OF NEW HAMPSHIRE
d/b/a EVERSOURCE ENERGY
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I. INTRODUCTION

Q. Ms. Ancel, please state your name, position and business address.

A. My name is Charlotte Barlow Ancel. I am Director of Clean Energy Strategy, Policy, and Development for Eversource Energy ("Eversource"). My business address is 780 North Commercial Street, Manchester, New Hampshire 03101.

Q. What are your principal responsibilities in this position?

A. On behalf of all of the Eversource operating companies including Public Service Company of New Hampshire d/b/a Eversource Energy ("PSNH" or the "Company"), I oversee and lead clean energy strategy and policy initiatives enterprise-wide, including the development of clean energy proposals like electric vehicles and battery storage.

Q. Please summarize your professional experience.

A. I joined Eversource in March 2018. For four years prior to that, I was Vice President of Power Supply and General Counsel at Green Mountain Power in Vermont. Previous to Green Mountain Power, I was a partner at the Burlington, Vermont law firm of Sheehey Furlong & Behm where I specialized in energy law.

Q. Please summarize your educational background.

A. In 2007, I received a Juris Doctor degree *magna cum laude* from the University of New Hampshire School of Law, where I served as Editor-in-Chief of the Law Review. Prior to attending law school, I taught high-school math and science to at-risk youth, first at Centerpoint School in Winooski, Vermont from 2001 to 2003, and then at Sand Paths Academy in the Mission District of San Francisco for the 2003 to 2004 school year. In 2000, I received a Bachelor of Arts degree *magna cum laude* from Boston College.

Q. Have you previously testified before the New Hampshire Public Utilities Commission or other regulatory agencies?

A. I provided testimony at the Vermont Public Utility Commission in Docket 17-3112 (Green Mountain Power rate case), Docket 8525 (rate integration and rate design), Docket 8794 (innovative services), Docket 8871 (regulation plan extension), and Docket 17-3232-8 (temporary limited regulation plan). I have not previously testified before the New Hampshire Public Utilities Commission (the “Commission”).

Q. Ms. Schilling, please state your full name, position and business address.

A. My name is Jennifer A. Schilling. I am the Director of Grid Modernization for Eversource Energy. My business address is 247 Station Drive, Westwood, Massachusetts 02090.

Q. What are your principal responsibilities in this position?

A. On behalf of all of the Eversource operating companies including PSNH, I am responsible for developing strategies to increase the capacity of the Eversource Energy electric distribution system to optimize the integration of distributed energy resources, while improving the safety, security, reliability and cost-effectiveness of the system. I am also responsible for grid-modernization portfolio management, as well as coordination and implementation of grid-modernization technology programs.

Q. Please summarize your professional experience.

A. From 2001 to 2008, I held a number of positions at Reliant Energy in Houston Texas, ending my tenure in the position of Director, Corporate Strategy. In 2008, I joined the Northeast Utilities System as the Director of Business Planning for Western Massachusetts Electric Company ("WMECO"). I subsequently accepted the role of Director, Asset Management for WMECO and then Director, Distribution Engineering for Eversource, prior to assuming my current role.

Q. Please summarize your educational background.

A. I graduated with a Bachelor of Arts degree in environmental science and political science from Barnard College, Columbia University in 1995. In 2001, I earned a Master of Business Administration from Duke University.

Q. Have you previously testified before the Commission?

A. No, I have not previously testified before the Commission. I have testified before the Massachusetts Department of Public Utilities in relation to grid-modernization and distribution planning matters as part of several different proceedings including D.P.U. 17-05 and D.P.U. 15-121/15-122.

Q. What is the purpose of your testimony?

A. Our testimony is provided on behalf of PSNH in support of the Company's Grid Transformation and Enablement Program ("GTEP"), which is a program to raise the condition of the Company's distribution system in the State of New Hampshire to a level that is necessary to meet the growing expectations of customers for fewer service interruptions; shorter restoration times, particularly following major weather events; and the integration of a range of advanced energy solutions that achieve operational goals, while at the same time reducing greenhouse gas emissions. The GTEP would operate in concert with the Company's core capital program to provide critical support for accelerated investments targeted to fortify the overhead distribution system with more resilient equipment and materials, while at the same time creating the operating platform necessary to enable the integration of advanced technology solutions on a cost effective and lasting basis.

If approved by the Commission, the GTEP would enable the Company to identify, plan and develop projects to meet customer demand for increased system integration of clean energy technologies in the future. As described in the joint testimony of Company Witnesses Joseph A. Purington and Lee G. Lajoie, the Company's GTEP testimony is provided in two parts. Our testimony is the second part of the GTEP testimony, describing two proposed demonstration projects that will serve as important learning opportunities as the Company continues to enable the integration of new and emerging clean energy technologies into the electric distribution system. These two projects are the Westmoreland Clean Innovation Project and the Oyster River Clean Innovation Project.

Q. What was your role in developing the demonstration projects discussed in this testimony?

A. Ms. Ancel is principally responsible for the development and presentation of the Westmoreland Clean Innovation Project. Ms. Schilling is principally responsible for the development and presentation of the Oyster River Clean Innovation Project.

Q. Ms. Ancel, would you please describe the Westmoreland Clean Innovation Project?

A. Yes. The Westmoreland Clean Innovation Project is designed to provide back-up power for hundreds of rural customers and critical town facilities, while avoiding construction of a new electric distribution line and helping to reduce peak energy costs and greenhouse gas emissions for all New Hampshire customers. This non-wires alternative project would serve as an important demonstration for future energy storage projects in New Hampshire. Therefore, the Company is proposing to include this demonstration project in the GTEP.

Q. Ms. Schilling, would you please describe the Oyster River Clean Innovation Project.

A. Yes. The Oyster River Clean Innovation Project will be aimed at creating greater resiliency for electric service, while serving as an important learning opportunity to advance knowledge and expertise in relation to the deployment of other, future microgrid projects in New Hampshire. In partnership with the University of New Hampshire ("UNH"), the Town of Durham, and by pursuing research grant opportunities, the Company would construct a clean energy microgrid that will advance the use of technologies to improve system visibility and control capabilities, reduce greenhouse gas emissions, and allow the campus and adjacent portions of the Town of Durham to remain energized during a widespread power interruption. Therefore, the Company is proposing to include this demonstration project in the GTEP.

Q. Are you presenting any attachments in support of your testimony?

A. Yes, we are presenting the following six attachments in support of this testimony:

Attachment	Purpose/Description
Attachment GTEP-1	Pictures of Westmoreland Town Center and Residences
Attachment GTEP-2	Eversource Report – Westmoreland
Attachment GTEP-3	Doosan GridTech Report
Attachment GTEP-4	Benefit/Cost Analysis
Attachment GTEP-5	Oyster River Project Memorandum of Understanding

Q. How is your testimony organized?

A. In addition to this introductory section, our testimony is organized into the following sections:

- Section II presents the Company's proposal for the Westmoreland Clean Innovation Project. Ms. Ancel is principally responsible for this section of the testimony.
- Section III presents the Company's proposal for the Oyster River Clean Innovation Project. Ms. Schilling is principally responsible for this section of the testimony.

Q. Are there costs associated with these two demonstration projects and, if so, does your testimony address the Company's proposal for cost recovery?

A. Yes, there are certain capital costs and operating and maintenance ("O&M") expenses that the Company would incur to execute on the proposed demonstration projects. Recovery of these costs is discussed in the joint testimony of Company witnesses Eric H. Chung and Troy M. Dixon.

II. WESTMORELAND CLEAN INNOVATION PROJECT

Q. Ms. Ancel, what is your assessment of the current energy landscape?

A. The electric distribution grid was constructed using materials and construction methods prevailing a century ago, under circumstances where customers were served from a few large, centralized, and mostly fossil fuel-based generators. Electric use grew year-over-year providing revenues between base-rate cases.

Today, the script has flipped. In 1990, there were approximately 2,000 grid-connected generators in New England. Today, there are over 125,000 with exponential growth expected over the next decade. The emergence of distributed energy resources ("DER"), in particular solar photovoltaic, and on-shore and off-shore wind generation resources has taken hold as a result of precipitously declining costs and the availability of state and federal incentives.

As an example, in the summer of 2018 Massachusetts completed its first competitive off-shore wind procurement. The winning bid was to provide energy and renewable energy credits at a levelized cost of 6.5 cent / kWh. This is approaching the current 4.2 cent / kWh cost of buying on the wholesale ISO New England market (which is predominantly gas-fired). Five years ago off-shore wind cost around 20 cent / kWh. And subsequent off-shore wind procurements have the potential to decline from 6.5 cents.

PSNH is seeing similar transformation with respect to electric sales. Electric sales are now flat or declining in most of the country, including New England.

Electric sales are declining for positive reasons. First, energy efficiency has made significant gains, both at the state (energy efficiency program and building codes) and federal (increased research and development and appliance standards) levels. The proliferation of solar photovoltaic DER is also contributing to the decline of electric sales. These declines are partially offset by New Hampshire's economic growth.

With declining sales, customer rates will go up – even before taking into account other increasing costs. This is because there are fewer units (i.e., kilowatt hours) over which to spread the fixed costs of utility delivery infrastructure. This requires a reimagining of the electric grid and of the way in which PSNH serves its customers. We will need to move swiftly toward a decarbonized, decentralized future, while also maintaining a safe, reliable, and affordable electric system.

Q. Please describe the need for the Westmoreland Clean Innovation Project.

A. The electric grid is becoming increasingly reliant on flexible energy resources that can be turned up or down depending on whether the wind stops blowing, the sun goes behind a cloud, or if customers' energy use suddenly spikes. To properly manage the grid under these conditions, PSNH will need to strengthen its ability to optimize battery storage, energy efficiency, and demand response (including aggregated thermostats, electric vehicle chargers, water heaters, residential scale batteries, and other customer-owned and -sited devices).

The path for how these flexible resources will be integrated into the New Hampshire grid is less developed than for renewable resources, though the Commission and other stakeholders are currently evaluating options as part of the Grid Modernization Docket.

The use of flexible resources to better serve customers, to increase resiliency, and to reduce system costs and greenhouse gas emissions is of paramount importance to the future. It is with these values in mind that the Company has developed the Westmoreland Clean Innovation Project (the "Westmoreland Project").

Q. Would you please provide an overview of the Westmoreland Project?

A. The Westmoreland Project will involve the creation of a coordinated portfolio comprised of three components: energy efficiency, demand response in the form of a "bring-your-own-device" program that provides incentives for customer-owned batteries, thermostats and battery storage, and a PSNH-owned battery-storage unit. This coordinated portfolio will enable PSNH to avoid construction of a 10-mile overhead distribution circuit, dramatically improving reliability on a circuit that has historically experienced performance deficiencies. This coordinated portfolio will also reduce yearly and monthly peak demand, reducing costs for all New Hampshire customers.

The Westmoreland Project will make a small, rural New Hampshire town an object lesson in clean energy transformation, enabling a lower carbon, more distributed, and more resilient grid. The Westmoreland Project has benefit-cost ratio of above 1, so that it is anticipated to produce approximately $1.9 million in net savings for customers over its life, relative to alternatives. PSNH will rely on the Westmoreland Project to test and refine the vision for a larger, clean energy transformation model that we would look to roll out in New Hampshire—in partnership with other stakeholders—over the next several years.

Q. What is the scope of authorization that PSNH seeks in this case for the Westmoreland Project?

A. As I noted above, the Westmoreland Project will involve the creation of a coordinated portfolio of comprised of three components: energy efficiency, demand response in the form of a "bring-your-own-device" incentive program, and a PSNH-owned battery-storage unit.

In terms of the energy efficiency component, PSNH is requesting approval to utilize additional marketing and outreach efforts to target energy efficiency projects in Westmoreland as part of the Westmorland Project.

In terms of the demand-response component, PSNH intends to propose a Residential Demand Reduction Initiative as part of the 2020 Update for energy efficiency programs to be submitted in September 2019 as part of Docket No. DE 17-136. The targeted component of the Westmoreland Project will present customer opportunities for participation. PSNH does not request specific approval of the demand response component in this docket.

In terms of the PSNH-owned battery storage component, PSNH is requesting that the Commission review the Company's proposed Westmoreland demonstration project in this case and pre-authorize the Company's capital expenditure related to this program, estimated at $7 million as well as annual average of $140,000 in O&M expense for the battery component, as it did in Docket No. DE 17-189 for Liberty Utilities. The Company is not proposing to recover these amounts through the base rates that the Commission will set in this docket. Instead, the Company is requesting the Commission's approval of a separate rate mechanism through which recovery of costs for projects such as the Westmoreland Project could take place. In approving the Liberty Powerwall Pilot, the Commission stated that its pre-authorization meant that the utility's decision to commence development of the project would be deemed prudent, but that the

Commission would retain the ability to review the prudency of the utility's execution of the development of the project when the utility sought rate recovery of the fully-commissioned project at a later date. PSNH respectfully requests the same treatment here.

Q. Please provide an overview of the topics you will address.

A. First, I provide an overview of Westmoreland, New Hampshire and describe its current significant reliability challenges. Second, I describe the Company's internal process to evaluate a traditional poles and wires solution versus non-wires alternatives (i.e., efficiency, demand response, and distributed resources) to address the Westmoreland reliability challenge. Third, I describe the independent analysis if the Company's third-party consultant, Doosan GridTech, which examined technical feasibility, sizing and associated cost of the battery storage component of the non-wires alternative. Fourth, I lay out each aspect of the Westmoreland Project, including benefit-cost analyses and projected implementation schedule. Fifth, I explain the Company's plans to competitively bid the battery storage component of the Westmoreland Project and the advance community outreach that has already been done in Westmoreland. Lastly, I describe how the Westmoreland Project satisfies each of the criteria laid out in RSA 374-G:5.

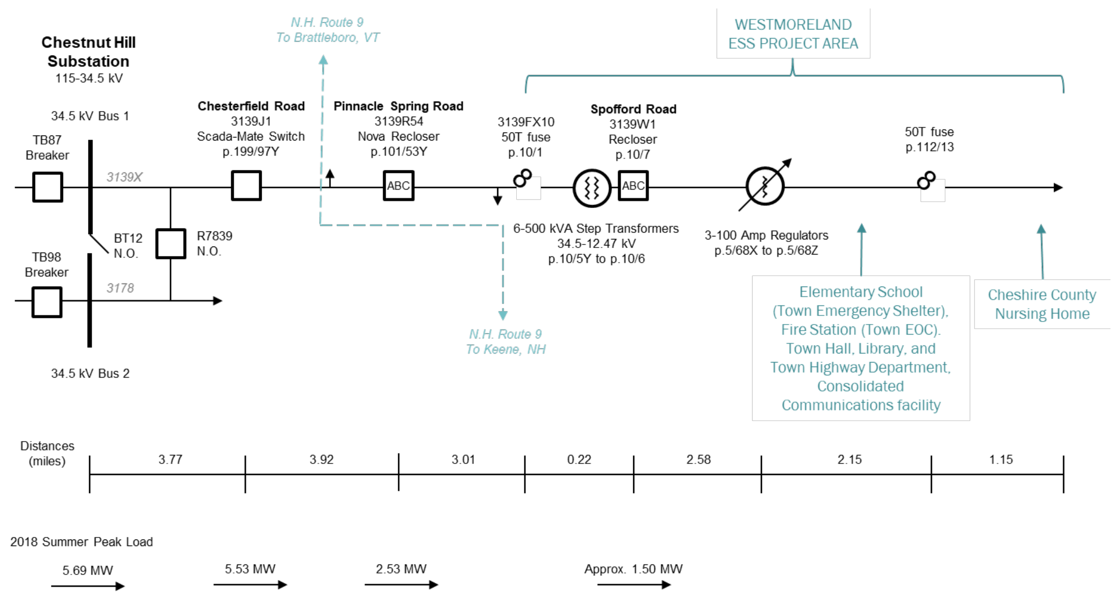
A. ***Westmoreland, New Hampshire***

Q. Please describe the municipality of Westmoreland, New Hampshire.

A. Westmoreland is located in Cheshire County in the southwest corner of the state. Its population is around 1,870 residents, consisting of around 570 households. A handful of small commercial customers are located in the town center, including an Elementary School, a Town Fire Station, a Town Hall, a Post Office, a General Store, a Consolidated Communications facility, and a Nursing Home. Westmoreland is mainly rural in character with a rolling landscape and a lot of tree cover. Pictures of the town center and some representative buildings are included as Attachment GTEP-1.

Most of the Company's customers in Westmoreland are served by a distribution circuit designated as "Line 3139X." The backbone of Line 3139X is a radial 34.5 kV line (not looped and therefore more prone to outages) that is approximately 16 miles long, connecting into the Chestnut Hill Substation in Hinsdale, New Hampshire and upstream of the Spofford Road transformers.

Visually, Line 3139X has the following configuration:



The Westmoreland town center is located approximately 14 line miles from the Chestnut Hill Substation and hosts critical loads including an elementary school (that serves as the town emergency shelter), the Town Fire Station, Town Hall, the Post Office, a General Store and a Consolidated Communications facility. The Cheshire County Nursing Home is located an additional two miles downstream of the town center.

Currently, service to these critical facilities is interrupted during outages in the upstream distribution system and there are no alternate sources of electricity available in the current system reconfiguration.

Since November 2012, there have been 13 outages on Line 3139X upstream of the Spofford step transformers (with an average duration of 2.2 hours and a maximum duration of 6.87 hours) and 24 outages downstream of the Spofford step transformers (with an average duration of 2.8 hours and a maximum duration of 8.68 hours).

All-in, customers in Westmoreland have experienced a total of 27 outages with a total duration of 97 hours with an average of 2.6 outage hours since November 2012. This is one of PSNH's worst performing circuits.

The traditional poles and wires solution to address this issue would be to construct a new, 10-mile distribution circuit serving the portion of Line 3139X downstream from the Spofford step transformers, feeding from the Emerald Street Substation in Keene, New Hampshire. The cost of this solution is estimated at approximately $6 million.

B. <u>The Value of the Demonstration Project</u>

Q. What is the Company's plan to address the limitations of service on Line 3139X?

A. Over time, the Company has evaluated options to change the situation on Line 3139X, but options for doing so are limited. In the past PSNH has generally reviewed potential non-wires alternative projects in conjunction with its system-planning efforts but has not had the opportunity or flexibility to develop creative solutions involving technology that is only recently emerging in the marketplace. Today, options are emerging as "non-wires alternatives," which are configurations that use non-traditional transmission and distribution ("T&D") solutions, such as energy efficiency, demand response, distributed generation, energy storage, and/or grid software and controls to defer or replace the need for specific equipment upgrades such as T&D lines or transformers, such as by reducing load at a substation or circuit level to alleviate a capacity constraint, or by providing an alternative solution to a reliability concern. Where non-wires alternatives can be utilized, there is the potential to produce multi-dimensional benefits for customers in the form of cost savings, reliability improvement and peak demand reduction that would not be available with the straightforward replacement or installation of a new distribution circuit.

In mid-2018, PSNH commenced a cross-functional review of potential opportunities across the system to implement non-wires alternative projects as part of an overall transition that would accelerate investment for targeted replacement of overhead distribution infrastructure and upgrade the condition of the distribution system to meet customer demands. As part of that effort, PSNH considered the following factors:

- Whether loads exist in the area at reasonable levels for demonstration project sizing;
- Whether reliability, capacity, or power quality issues are present that could be solved by the project;
- Extent of DER penetration;
- Whether the project would enable the Company to avoid or defer traditional system upgrades – especially in difficult to reach locations which lead to higher costs, considering the following:
    - Substation loadings
    - Feeder loadings
    - Back-up capabilities – single feed or single transformer substations, no current alternate distribution line loops

    - Critical customer locations.
- Land availability in the area.

The highest scoring project among 11 potential sites across New Hampshire identified by PSNH was the Westmoreland Project, involving a combination of energy efficiency, demand response, and battery storage for Line 3139X in lieu of installing a traditional 10-mile distribution circuit. This project scored highest due to reliability and power quality needs in the area; the need for back-up capability in a difficult location to provide traditional solution; expected land availability in the area; and, loads at levels appropriate for demonstration project sizing.

Q. How did PSNH approach the targeted energy efficiency component of demonstration project?

A. PSNH's Energy Efficiency team evaluated the potential to concentrate additional efficiency investments into the Town of Westmoreland as part of the effort to avoid the traditional distribution upgrade. From a customer-base perspective, the Town of Westmoreland encompasses:

- 3 large commercial customers (with one customer accounting for the bulk of annual kilowatt usage);
- 76 smaller commercial customers (with 16 customers accounting for the top usage);
- 13 interruptible electric heat customers; and
- 448 residential customers.

PSNH plans to use additional marketing and outreach to target these customers for participation in the Company's existing programs. This will include reviewing the usage of customers downstream from the battery, identifying energy efficiency opportunities at commercial, industrial, municipal and residential customer sites, and working directly with those customers to implement energy efficiency improvements. The Company's strategy will use direct customer contact via account executives to commercial, industrial and municipal customers as well as direct mail marketing to the residential customers who are identified as qualifying for weatherization or replacement of / upgrading to more efficient lighting and appliances. Based on all these efforts, the Company expects to obtain approximately 50 kW of additional reduced load in the Town of Westmoreland. A detailed report laying out this proposal is attached as Attachment GTEP-2.

Q. Would this targeted energy efficiency effort require incremental funding through the Company's proposed mechanism?

A. No. PSNH is not proposing funding for this component as part of the demonstration project. Instead, this effort could be funded through programs already in place and funded by <u>existing</u> system benefits charge ("SBC"). In that regard, RSA 374-F:4, VIII(e) states that utilities *shall* make a proposal for use of SBC funds that are used as a part of a targeting strategy to minimize distribution costs and that such proposals would be implemented on a pilot basis. This is such a project. Therefore, PSNH is proposing to use existing energy efficiency program offerings to implement efficiency projects in Westmoreland, including additional outreach and marketing to encourage uptake from customers in the community.

Q. You also mentioned a targeted demand response effort as part of the Westmoreland Project. What does this mean?

A. Yes. PSNH has developed the concept of establishing a "Bring Your Own Device" Program ("BYOD") throughout its New Hampshire service territory, with a targeted quantity of 65 kW of such devices in Westmoreland serving as one of the first locations.

Q. What is a "Bring Your Own Device" Program?

A. The BYOD design would enable PSNH to pay an incentive for verifiable load reductions using a customer-owned behind the meter device based on actual performance (meaning the customer's behind the meter device actually responded to the utility's dispatch signal). This design would protect non-participating customers because, where a customer who has received an up-front incentive does not perform, the utility typically has little actual recourse to recoup any of the large upfront funds paid to the participating customer. This outcome represents a loss to all non-participating customers who have paid into the energy efficiency fund. Within the Company's concept, non-participating customers are protected against non-performance by utilizing a design that only pays for actual dispatches and load reductions rather than an up-front incentive payment.

In this model, PSNH would send a signal to the device manufacturer or customer to execute a command and the device manufacturer or customer will then send a signal to each device to temporarily change their normal operations, resulting in load reductions. PSNH would then pay an incentive based on a customer's performance. Typical devices that participate in BYOD programs include wi-fi thermostats connected to central cooling systems, behind the meter battery storage systems, water heaters, and electric vehicle chargers. The Company's goal would be to produce approximately 65 kilowatts of demand reduction in the Town of Westmoreland.

Customers who are able to utilize their own onsite battery storage during an outage will not be reliant on the larger battery for power in the case of an outage. This allows PSNH to reduce the size of the front of the meter storage system to effectively meet its goals to significantly improve reliability for the Town.

As part of this initiative, PSNH would reserve a number of participant opportunities (likely 10 out of a potential 50 total for battery storage; 30 out of a potential 250 for communicating thermostats) for customers located in Westmoreland, to provide the opportunity for further kilowatt reduction in the community, additional peak shaving impact, as well as added resiliency for residents utilizing their own batteries. If customers in the town of Westmoreland do not sign up for all of the set aside participant opportunities by May 1, 2020 those "reserved" opportunities will be opened up to customers in the rest of the state.

The Company envisions a typical customer offering under the BYOD Program would be as follows: For a customer with an existing wi-fi thermostat and central cooling, PSNH would offer the customer a $25 sign-up bonus and an annual $20 performance payment for allowing PSNH to increase the customer's thermostat set point by up to 4 degree for 3 hours at a time, 15-18 times per year.

Similarly, PSNH would pay an incentive to a customer that installed a residential battery storage system and allow the Company to dispatch that battery some number of hours per year. A typical example would be as follows: A customer installs a Tesla Powerwall and allows PSNH to dispatch the Powerwall multiple times over the summer for PSNH to reduce its annual peak load. The customer would receive $200/kW which translates to earning $1,000/year.

There are typically variations of the incentive level depending on how often the battery is controlled by the utility. PSNH would consider integrating other devices that customers may already have in their homes and that could connect to a central platform in order to receive dispatch instructions. The incentive would be based on how frequently these devices could be dispatched and the level of load reduction that device could provide. Actual incentive levels will be determined during the 2020 Update in DE 17-136.

All of these offerings will be wholly voluntary and consistent with RSA 374:62.

Q. Is PSNH proposing to own any of these behind the meter batteries or other devices?

A. No.

Q. How is PSNH proposing to fund the BYOD Program?

A. PSNH, along with the other New Hampshire utilities, will file a 2020 Update for energy efficiency programs in September of 2019 in Docket No. DE 17-136. As part of that

2020 Update, PSNH intends to propose a Residential Demand Reduction Initiative. This residential effort will build off the C&I Demand Reduction Initiative that was included in the 2019 energy efficiency programs and approved by the Commission in Order No. 26,232 (April 5, 2019).

The overall demonstration project for Westmoreland would use the "reserved" portion of the BYOD as described above; however, the Company's statewide proposal and the associated funding would be included in the 2020 Update. Assuming the residential demand reduction proposal in the 2020 Update is approved, it would be implemented statewide with PSNH focusing on deployment in Westmoreland as a demonstration project proposed in this case.

Q. Would you please summarize the level of kilowatt hour savings you are expecting in total from the geotargeted efficiency and demand response components of the Westmoreland Project?

A. Yes. The estimated summer demand reductions resulting from these energy efficiency and demand reduction initiative are estimated as follows:

	Westmoreland		Statewide	
Project Component	**Quantity**	**Total kW**	**Quantity**	**Total kW**
Energy Efficiency	15	50		
Residential Batteries	10	50	50	250
Communicating Thermostats	30	15	250	125
Total	**55**	**115**	**300**	**375**

Q. Did the Company consider whether the reliability issue could be addressed by other alternatives such as adding a new generation source at the end of the circuit?

A. Yes, but PSNH determined that this alternative would be significantly more expensive than the battery solution. Moreover, there would not be enough energy efficiency and/or demand response to offset reliability concerns.

C. <u>Third Party Analysis</u>

Q. What steps did PSNH take to confirm the foundational concepts of this demonstration project with an industry expert?

A. To confirm the foundational elements of the demonstration projects, PSNH commissioned Doosan GridTech ("Doosan") to evaluate the feasibility, sizing, and cost of the Westmoreland Project (focusing specifically on the battery storage component). Doosan examined the Line 3139X electrical system, presented a conceptual design for battery storage paired with efficiency and demand response, and assessed the benefits achievable through such a portfolio of approaches connected in Westmoreland. Doosan's full report is provided herewith as Attachment GTEP-3.

Q. Would you describe Doosan's conclusions?

A. Yes. Doosan recommended a 1.7 MW / 7.1 MWh lithium ion battery to avoid construction of the 10-mile distribution line.

Doosan determined that a 1.7 MW / 7.1 MWh system would support all commercial and residential loads downstream of the Spofford step transformers through all upstream outages up to 4-hours in duration based on projected load through 2028. The 1.7 MW / 7.1 MWh rating is an "end-of-life" rating, thus accounting for degradation. I refer to the "end-of-life" value as that is the size needed to avoid the traditional "poles-and-wires" asset.

The battery is a favorable solution for Westmoreland as it will significantly reduce the number of outages at a comparable level to a traditional "poles-and-wires" solution. A new distribution circuit would not have the duration constraints of a battery but would be more prone to outages caused by storms and other upstream issues. Based on historic data, we estimate that the battery would have improved reliability by approximately 80% had it been service since November 2012.

Doosan also determined that additional qualitative benefits could result from the project, such as the potential for primary frequency response capability and the development of expertise in leveraging the benefits of battery storage by the PSNH team. These benefits are not directly quantifiable and are not included in the Company's benefit-cost analysis.

Doosan recommended lithium ion battery technology based on its technological maturity and suitability to perform the recommended use cases. Doosan also relied on PSNH's energy efficiency projections that an additional 50 kW could be obtained through energy efficiency measures and 65 kW through demand response. These demand reductions increase the ability of the proposed energy storage system to serve longer duration outage events beyond the 4-hour window provided by the utility-scale battery.

Doosan estimated that the all-in capital cost of the battery storage component of the Westmoreland Project would be approximately $7 million based on its expertise regarding expected engineering, procurement and construction ("EPC") pricing, as well as its knowledge of indicative pricing, market research they performed, and third-party market analyst numbers. Doosan also considered cost estimates for development, siting and permitting, interconnection costs and other PSNH-specific costs to implement and commission this type of project.

The estimate is summarized as follows:

Capital Cost Elements	Amount ($000)
EPC costs	$4,328
Permitting and Site Development	$738
Interconnection and Integration	$344
Engineering, Project Management, and other internal costs	$1,491
Total Capital Cost	$7,002

The battery would also require an average of $140,000 in O&M per year. This would cover station service, service/maintenance, warranty, and insurance. Doosan estimated that the battery storage component of the Westmoreland Project would take approximately 18 months to implement from issuance of a Commission decision approving this proposal.

Based its comprehensive analysis, Doosan concluded that the Westmoreland location is uniquely situated to use energy storage, energy efficiency and demand response to avoid construction of a new 10-mile distribution circuit.

D. Benefit-Cost Ratio

Q. Has PSNH evaluated the direct savings from the Westmoreland Project as compared to its costs?

A. Yes. PSNH evaluated the benefits and costs of the battery storage component as that is the only aspect of the Westmoreland Project that would be included in the cost-recovery mechanism for the Grid Transformation and Enablement Program. Cost-effectiveness screening for the efficiency and demand response components would be determined in the respective dockets, as described above.

The battery installation has a benefit/cost ratio of 1.19. The benefit-cost analysis model is provided herewith as Attachment GTEP-4.

The benefit-cost analysis is based on a Utility Cost Test ("UCT") which considers the costs and benefits from the perspective of all PSNH customers. A net benefit flows directly to customers. The analysis includes only direct costs and benefits, and not other non-energy benefits. Over the Westmoreland Project's lifetime, the net present value of the net benefits it will provide for customers is approximately $2 million.

Q. Would the battery have benefits beyond avoiding a new 10-mile distribution line?

A. Yes. Along with avoiding the 10-mile distribution line, the battery would also be used to reduce monthly and annual peak demand. Reducing peak demand results in benefits associated with energy supply and transmission. I will describe these benefits in greater detail in just a moment.

Q. Would you please discuss the benefit-cost analysis that PSNH conducted for the battery storage component of the Westmoreland Project in greater detail?

A. Yes. I will describe the analysis behind costs, benefits, and how PSNH uses those numbers to calculate the benefit-cost ratio.

<u>Costs</u>:

As discussed above, PSNH commissioned Doosan to develop cost estimates—both capital and O&M—for the battery component of the Westmoreland Project. The Company validated Doosan's cost estimates by reviewing the estimates alongside contracts for battery projects that the Company's affiliate is developing in Massachusetts.

After validating Doosan's estimates, the Company calculated the annual revenue requirement associated with the capital for the battery. The Company conducted a separate analysis to calculate the revenue requirement associated with the non-battery aspects, such as the site preparation and interconnection, and the revenue requirement associated with the lithium-ion specific components, which have a shorter life due to degradation of the battery cells. PSNH also assumed, under the guidance of Doosan, that $1.2 million in capital would need to be deployed after 12 years due to the degradation of lithium-ion cells. The Company included that capital addition in its analysis as a conservative assumption and to not misrepresent total lifetime costs, though PSNH is not requesting approval for those expenditures at this time.

Benefits:

There are two categories of benefits for the battery. The first category is the avoidance of a traditional "poles and wire" solution. As discussed above, the battery will be part of a non-wires alternative that enables PSNH to avoid building a 10-mile distribution circuit, at an estimated cost of approximately $6 million. The Company calculated the revenue requirement associated with the traditional solution as the traditional asset avoidance benefit.

The second category of benefits is peak reduction. Reducing peak load enables PSNH to avoid costs relating to the bulk transmission system (called Regional Network Service, ("RNS")), local transmission network (called Local Network Service, ("LNS")), and supply (by avoiding capacity payment obligations in the Forward Capacity Market ("FCM")). As discussed above, the 1.7 MW / 7.1 MWh rating is the "end-of-life" rating for the battery. We use the "end-of-life" rating, which accounts for degradation, instead of the "beginning-of-life" rating as a conservative assumption.

In Docket No. DE 17-189, the Commission approved Liberty Utility's Tesla Powerwall pilot, which included assumptions for both RNS and FCM avoidance. We have followed the approach that was approved in that docket.

RNS: In Docket No. DE 17-189, Liberty utilized a forecast of RNS through 2022, then assumed an increase of 4.66% year-over-year for the remaining years of the analysis.[1] That increase is consistent with the implied year-over-year increase in the RNS forecast utilized by Liberty. Our analysis utilizes the same RNS levels and growth rate as Liberty's analysis.[2]

FCM: In Docket No. DE 17-189, Liberty included an FCM rate consistent with the Avoided Energy Supply Costs ("AESC") 2018 Wholesale Capacity Value pricing, which New Hampshire utilities use to calculate cost avoidance for energy efficiency programs.[3] This forecast includes Forward Capacity Auction ("FCA") prices ranging from $100/kW-Yr on the high end to $57.6/kW-Yr on the low end, with year-over-year changes that vary. With respect to historical auction prices, the most recent auction, FCA 13, cleared at $45.6/kW-Yr, while previous auctions have been above $100/kW-Yr, with volatility from one auction to the next. The average of the last five auctions has been approximately $79.5/kW-Yr. The analysis uses the FCA 11 clearing price of $63.6/kW-

[1] Docket No. DE 17-189, Technical Statement of Heather M. Tebbetts, Nov. 15, 2018 at 4 (submitted as part of a settlement agreement on Liberty's proposal).

[2] RNS Rates: 2018-2022 PTF Forecast, presented at the NEPOOL Reliability Committee/Transmission Committee Summer Meeting, Aug. 7-8, 2018 and available at the following link: https://www.iso-ne.com/static-assets/documents/2018/08/a2.0_2018_08_07_08_rc_tc_ptoac_forecast.pptx

[3] Docket No. DE 17-189, Technical Statement of Heather M. Tebbetts, Nov. 15, 2018 at 4.

Yr and grow it at inflation (2%) to represent a reasonable price given historical volatility. This assumption results in similar values to what Liberty included in its analysis; but, has less year-over-year volatility.

LNS: In Docket No. DE 17-189, Liberty reviewed its bills associated with LNS to develop a $/kW-Yr LNS rate starting in the mid-$20 range. The analysis includes a lower LNS rate—starting at $10/kW-Yr and growing at inflation (2%). This is consistent with a review of the Company's historical data. While there is inherent uncertainty around LNS rates on a year-over-year basis, PSNH chose to use the lesser rate as a conservative assumption.

After calculating the revenue requirement necessary for the traditional "poles and wires" solution and adding the RNS benefit to the FCM benefit to calculate a total peak reduction benefit, PSNH calculated the net present value of all the benefits. The Company then divided the net present value of the costs (revenue requirement of the battery project) by the net present value of the benefits to calculate the benefit/cost ratio for the utility-scale battery project of 1.19.

Q. Overall, how do the assumptions underlying the PSNH benefit-cost analysis differ from what was approved in Docket No. DE 17-189?

A. The Company's analysis follows the same structure as what was approved as part of the Settlement Agreement in Docket No. DE 17-189, but with a few key differences which I will discuss.

First, with respect to costs, the Company models costs being recovered for the battery over a 25-year horizon with the battery's lithium ion cells being replaced after 12 years. Liberty's Battery Pilot Project will recover costs for the battery component over a 10-year period, consistent with the warranty for the Tesla Powerwall. While the 10-year horizon was appropriate for Liberty's approach to deploying small, distributed batteries, the 25-year horizon is appropriate for a large, utility-scale project.

Liberty's pilot also included a customer Contribution In Aid of Construction ("CIAC"). The Project is a front-of-the-meter project which does not include a customer contribution. The full cost of the battery is thus included in the calculation for the revenue requirement associated with the costs in the benefit-cost analysis.

With respect to benefits, Liberty assumed that the Tesla Powerwalls would have a 15-year useful life. That is 5-years behind the book life used to calculate the annual revenue requirement for the Tesla Powerwalls and is consistent with industry expectation for Tesla Powerwalls. The Company models benefits on the same time horizon as cost recovery—25 years. While the useful life of the proposed battery at Westmoreland may be beyond 25-years, we used the same time horizon as the cost recovery of the project to be conservative in the analysis.

Some of the benefits included in the model also differ from what was approved in Docket No. DE 17-189. As discussed above, the analysis uses the same forecast for RNS, lower rates for LNS, and relatively similar rates for FCM (but with less volatility). The analysis also assumes that PSNH will be able to hit 83.3% of peaks, meaning that PSNH intends to hit the annual peak in most years, and in 10 of 12 monthly peaks in an average year. In Docket No. DE 17-189, Liberty assumed it would hit 75% of peaks, or hitting the annual peak in most years and 9 of 12 monthly peaks in an average year. The proposed Westmoreland battery is a longer duration (4-hours) than the Tesla Powerwalls included in Docket No. DE 17-189 (2.7 hours). A longer-duration battery can discharge over a longer timeframe thus easing the ability to hit a specific one-hour peak. Furthermore, a single, front-of-the-meter battery should have fewer dispatch issues than behind-the-meter assets, as there will be no opt-out or premise-specific issues.

The analysis also includes the benefit of traditional asset avoidance. The project will avoid a $6 million distribution line. In Docket No. DE 17-189, Liberty discussed the possibility of asset deferral but did not include it in its financial analysis as a direct benefit. The project is being designed and sized for the primary purpose of meeting a local need and thus avoiding the development of a traditional asset.

E. Peak Forecasting Methodology

Q. Does Eversource have experience in forecasting peaks?

A. Eversource has been successful in dispatching resources to reduce annual peak load in Massachusetts. The methodology to forecast the annual peak hour will be expanded upon to forecast monthly peaks and dispatch resources accordingly for PSNH.

Currently, our peak forecast methodology has three pillars:

1. Third-party vendor: We employ a third-party vendor who uses a proprietary methodology to forecast if a peak day is in the near future. While we currently use the third-party vendor for insight on annual peaks, the methodology will be expanded to also forecast monthly peaks, as to realize RNS/LNS benefits.

2. ISO-NE 7-day forecast: ISO-NE publishes a 7-day forecast which is updated daily. We review the ISO forecast on a daily basis to gain insight into the outlook for regional peak demand.

3. Internal modeling: Our forecasting team generates a 7-day econometric forecast which considers weather, day type, month, holidays, and energy usage from previous days.

Our team reviews each of these sources to make a judgment whether there may be an upcoming peak. Leveraging multiple sources mitigates risks associated with forecast uncertainty.

Q. How will PSNH forecast monthly peaks?

Monthly peak forecasting presents a greater challenge than annual peak forecasts. This is because the annual peak is driven primarily by weather. Multiple hot and humid days will lead to peak conditions. The spring and fall months, however, often do not experience such a direct link between weather and peak conditions. This is because heating and air conditioning is less likely to be in use, regardless of moderate temperature fluctuations.

Leveraging multiple sources, along with historical data, will enable PSNH to hit peaks in the spring and fall months. While weather is not as highly correlated with consumption as in the summer, it is still one of the main drivers of peak load, especially because monthly peaks are often affected by the output of behind-the-meter solar, which is highly dependent on weather conditions.

Deploying the battery as a front-of-the-meter asset will further enable PSNH to hit monthly peaks. Customer-sited resources that a utility dispatches often have stipulations regarding how often the utility can send a dispatch signal. With respect to a front-of-the-meter battery, PSNH can frequently charge and discharge the battery without risking customer inconvenience or attrition. If forecasts indicate that there are multiple days which may be the monthly peak, we can dispatch the battery on any or all of those days.

F. ***Cybersecurity Risk Mitigation***

Q. What protocols will PSNH follow to mitigate cybersecurity risk?

A. Rigorous cybersecurity standards will be in-place to ensure confidentiality with respect to Personal Identifiable Information and security with respect to Critical Infrastructure Information.

For the front-of-the-meter battery, PSNH will use established vendors and control systems with a proven track record of rigorous cybersecurity protocols. The developer of the battery will be required to adhere to the Company's strict security standards, consistent with RSA 363:38.

With respect to deploying behind-the-meter assets as part of the targeted energy efficiency and demand response program, PSNH will use the rigorous protocols Eversource has in place in Massachusetts. As I explained earlier, we have been successful in dispatching customer-sited resources in Massachusetts. Vendors who install and control customer-sited resources are required to go through rigorous review processes including a Due Diligence Questionnaire, a Project Security Sign-Off, and other process reviews.

G. Plans to Competitively Bid the Battery Storage and Local Outreach

Q. Is PSNH planning to competitively bid the battery storage component?

A. Yes. PSNH will solicit competitive bids for the EPC contract associated with the 1.7 MW/7.1 MWh battery storage component. In the context of this solicitation, the Company will follow a disciplined process conducted by the same procurement team that leads negotiation and vetting of all the Company's contracts, including major substation transformer projects.

The Company plans to issue its solicitation of bids to a broad field of leading energy storage EPC vendors. The Company will vet the bids submitted by participating vendors to develop a short list. This first-stage evaluation will be based on each vendor's safety record; financial solvency (particularly important given that the battery storage will be relatively new technology, but long-lived assets); prior similar battery storage projects completed on time and on budget); and, engineering and project management expertise. The Company will then seek full and formal bids from these short-listed vendors. A cross-functional team will review and rank the bids based on cost and the strength of the technical design and project plans. PSNH will complete negotiations with the leading vendor on terms that are cost-effective for customers and include appropriate warranties and other protections. The successful vendor will then complete in full the design portion of the battery storage component, procure all necessary equipment, and construct and commission the battery.

Q. How are you proposing to measure the battery's ability to deliver all the values to PSNH customers that you have described?

A. PSNH expects to finalize the specific areas of study prior to commencement of the project as well as specific use cases, data gathering and measurement, and assumptions the Company is seeking to validate. To evaluate the technical and non-technical benefits of the Westmoreland Project on an on-going basis, the Company expects to complete an annual report for each year of the project and to file these annual reports with the Commission.

Q. Would you please describe the outreach that the Company has made with the Town of Westmoreland on the project?

A. We have briefed town leadership (Town Manager, Town Select Board, Town Facilities Officer, county leadership (County Commissioners), and other town representatives (school, nursing home, and local businesses) on the Project. Responses have been uniformly positive. We are also planning an open house event in June to brief town residents and businesses.

H. Compliance with RSA 374-G:5

Q. Would you please explain how the Westmoreland Project satisfies each of the criteria laid out under RSA 374-G:5?

A. Yes. The PSNH-owned battery component of the Westmoreland Project falls under the umbrella of projects covered by RSA chapter 374-G. Therefore, I will walk through the factors encompassed in RSA 374-G:5 and discuss the proposed demonstration project in relation to those factors.

Overall, the proposed project is a reasonable size given PSNH's significant footprint in New Hampshire. The project is an important demonstration of how a reimagined grid can be more cost effective, more reliable, and cleaner than the grid of the last century. The project will go out for competitive bids to promote market competition. Furthermore, the project will result in better understanding with respect to DER integration issues, customer experience and participation, load shape forecasting, and peak load forecasting.

(a) Effect on the reliability, safety, and efficiency of electric service.

The Westmoreland Project will significantly improve reliability and efficiency in relation to a distribution circuit that has experienced relatively frequent service interruptions. The battery will provide backup power to all customers in the area when there would otherwise be an outage. This includes providing power for critical loads such as an elementary school and a fire station.

When not serving as backup during an outage, the project will reduce peak load by shifting load from peak hours to hours when demand is lower. This will increase the overall efficiency of the grid.

The battery component will be competitively procured under the highest standards for safety and efficiency. The battery technology is a relatively mature technology (lithium ion) and will be developed by a thoroughly vetted and well-qualified developer. The battery's operations will leverage established control systems. The efficiency and demand response components will likewise follow best practices.

(b) Efficient and cost-effective realization of the purposes of the renewable portfolio standards of RSA 362-F and the restructuring policy principles of RSA 374-F:3.

Although the Westmoreland Project will not directly produce renewable energy certificates to meet the renewable portfolio standard, the battery will nonetheless support a cleaner grid. During peak hours, demand is met by dispatching thermal generators that are less efficient than generators that run when demand is lower. By exporting energy at peak hours, the battery will reduce overall emissions from these less efficient thermal generators. The Westmoreland Project will also foster competitive markets by (1) ensuring customer and third-party ownership of the behind the meter batteries, and (2) putting the engineering, procurement, and construction of the battery component out for competitive bid by third parties.

(c) Energy security benefits of the investment to the State of New Hampshire.

The Westmoreland Project will provide an opportunity to test and refine the PSNH vision for a clean energy transformation model that the Company is advancing in New Hampshire—in partnership with other stakeholders—over the next several years. During service interruptions, the battery component will be able to provide energy to keep the lights on for Westmoreland customers. The efficiency and demand response components will make the duration of the battery last longer by reducing the amount of load to be served on the circuit. This will decrease the exposure of New Hampshire customers to regional grid outage events.

(d) Environmental benefits of the investment to the State of New Hampshire.

The Westmoreland Project is anticipated to reduce overall load and also to shift load away from hours when customer requirements would otherwise be met with higher-emitting, lower-efficiency generators. Therefore, peak reductions are expected as a direct result of the Westmoreland Project.

Furthermore, the project will be an important demonstration of how a reimagined grid can be more cost effective, more reliable, and cleaner than the grid of the last century. The success of this project will further open the toolboxes of New Hampshire's utilities to provide more resources to realize a cleaner and more reliable grid of the future.

(e) Economic development benefits and liabilities of the investment to the State of New Hampshire.

With respect to economic development and liabilities of the investment, PSNH will utilize local labor as much as possible to deploy the project via competitive procurement. Local labor will gain experience working with a newer technology, which will become more and more prominent in utility toolboxes in the future. With respect to economic "liabilities," the costs associated with the project will be recovered from PSNH customers to the extent that costs are determined by the Commission to be prudently incurred. The benefit/cost ratio for the project is greater than 1.0, which means that the project is expected to result in net savings relative to other alternatives.

(f) Effect on competition within the region's electricity markets and the state's energy services market.

The Westmoreland Project is designed to promote market competition and to reduce costs. PSNH plans to competitively bid the battery component of the project and is not proposing to own any behind the meter resources. Instead, PSNH will work with customers to help maximize the value of their assets, which would be provided by competitive vendors without restriction by PSNH.

(g) Costs and benefits to the utility's customers, including but not limited to the demonstration that the company has exercised competitive processes to reasonably minimize costs of the project to ratepayers and to maximize private investment in the project.

The battery component of the project will have a benefit/cost ratio of greater than 1.0, meaning that there will be net savings for customers when compared to other alternatives. Furthermore, the Westmoreland Project is designed to rely heavily on competitive procurements for the utility-scale battery. For the targeted energy efficiency and demand response component, PSNH does not intend to own any behind-the-meter resources, ensuring that customers can realize the full benefits of market competition. To the extent that other customer funds might be used for the energy efficiency and BYOD segments of the project, the benefit-cost analysis would take place in that context.

(h) Whether the expected value of the economic benefits of the investment to the utility's ratepayers over the life of the investment outweigh the economic costs to the utility's ratepayers.

There is overlap between this point and the previous point, and as such, this requirement is already addressed in part (g). That is, the benefit-cost ratio for this program is greater than 1.0.

(i) Costs and benefits to any participating customer or customers.

The battery component of the Westmoreland Project is a front-of-the-meter project that does not necessitate participation from specific customers. The behind-the-meter aspect of the project will enable participating customers to realize increased reliability and resiliency, along with any other value streams the host customer sees fit to pursue. PSNH is proposing entirely voluntary participation, so each individual customer can decide if the relevant benefits and costs make sense for their individual situation.

Q. Is the Westmoreland Project consistent with PSNH's planning process, as discussed in the Least Cost Integrated Resource Plan ("LCIRP")?

A. Yes. PSNH developed the proposed Westmoreland Project consistent with the planning process discussed in the Company's most recent LCIRP submitted in Docket No. DE 15-248. Appendix A of the LCIRP discusses the four major stages of the Company's planning process. These stages are:

1) the gathering of historical loading, equipment, and reliability data;
2) preparing the forecast for peak electric demand;

3) evaluating the alternative solutions to projected overloads or operating violations, including potential elements of transmission, substation, distribution line, conservation & load management and/or distributed generation; and

4) determining the load-driven, aging infrastructure, and reliability projects that will be supported by the capital budget by review of various factors including equipment loading risk, equipment failure risk, reliability benefit, regulatory requirement, safety, and environmental impacts or benefits.

The Westmoreland Project was devised through a rigorous process consistent with these planning stages. The process to identify Westmoreland included gathering data related to reliability, capacity, power quality, loading and DER penetration. PSNH's cross-functional team identified historical reliability and power-quality issues in the Westmoreland Project area and then reviewed the forecast for peak electric demand to ascertain if the issues may persist.

In evaluating potential alternative solutions, the team identified battery storage in combination with targeted energy efficiency as a solution to reliability and power quality issues in Westmoreland. The Westmoreland Project was proposed for inclusion based upon its reliability and environmental benefits and will result in net benefits for New Hampshire customers, supporting the intent of the "least cost" philosophy.

III. OYSTER RIVER CLEAN INNOVATION PROJECT

Q. Ms. Schilling, why is it important for the Company to submit this proposal at this time?

A. The traditional electric utility business model is evolving and the pace of change is rapid and accelerating. There are three transformational forces driving change in the utility industry: (1) state energy and environmental policy; (2) changing customer expectations and the level of customer engagement; and (3) new and emerging technologies that are declining in cost over time.

At the state level, the *New Hampshire 10-Year State Energy Strategy*, identifies "[e]nsuring a secure, reliable, and resilient energy system" as one of the key goals to improve state energy policy to better meet consumer needs.[4] In addition, electric system resiliency is becoming increasingly important as virtually every sector of the state's economy depends on electricity as homes and businesses come to rely more and more on technologies that require electricity. The extent of this dependence is underlined when a significant storm event is experienced in the region. Overlaying this backdrop of state energy policy and customer expectations are advances in clean renewable energy, battery storage, and automated distribution system technologies that are evolving at a rapid pace.

These transformational forces are changing the way in which electricity is generated, distributed, managed, and consumed. To keep up with the pace of change, and enable continued progress, the Company must explore new business models and embrace new technologies that will further enhance resiliency, meet changing customer expectations, and promote the state's energy and environmental priorities. Microgrids have emerged as an innovative platform to integrate clean renewable generation, energy storage, and improve the resiliency of the electrical grid. Accordingly, the Company is proposing to

[4] *New Hampshire 10-Year Energy Strategy*, New Hampshire Office of Strategic Initiatives, April 2018, at 5.

include a microgrid demonstration project as part of its Grid Transformation and Enablement Program.

Q. What is a microgrid?

A. The U.S. Department of Energy ("DOE") defines a microgrid as:

> A group of interconnected loads and distributed energy resources with clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid [and can] connect and disconnect from the grid to enable it to operate in both grid connected or island mode."[5]

Microgrids typically include DERs, such as combined heat and power systems or solar photovoltaic generating systems and may be accompanied by a form of energy storage, customarily a battery or bank of batteries. A microgrid provides resiliency by balancing supply and demand resources within a defined area. Effectively, a microgrid is an "island" within the larger utility grid, shielding the customer(s) during extreme weather events with widespread power interruptions.

There are two broad categories of microgrids: (1) single-user microgrids; and (2) multi-user microgrids. Under the single-user model, there is one user, all the assets are typically owned by one entity, and the microgrid is usually contained within a single contiguous building or property. The single-user model is nothing new and it has been deployed on college campus and hospital settings across the country for decades. The multi-user model is relatively newer and represents an evolving approach, expanding the

[5] *Summary Report*, 2012 DOE Microgrid Workshop, Office of Electricity Delivery and Energy Reliability at 1 (July 30-31, 2012), available at: https://www.energy.gov/oe/downloads/2012-doe-microgrid-workshop-summary-report-september-2012

microgrid architecture to serve multiple customers, multiple customer meters and multiple facilities.

Q. What are the benefits of microgrids to the distribution system?

A. The primary benefit of microgrids to the distribution system is enhanced operational flexibility to support improved reliability. The traditional distribution system design is radial, with power flowing one-way from the transmission system through bulk substations and out to load. In recent years, the Company has invested in distribution automation that has given operators tools to isolate outages on the distribution system to a defined segment and re-feed the unaffected segments from an alternate source of supply. The operational flexibility provided by this automation has provided significant benefit to customers by reducing the number of customers affected by an outage event.

Microgrids provide another layer of operational flexibility in system design to support extremely high reliability, regardless of the nature of the outage event. In the traditional model of system design, the ability to transfer load and re-feed customers in the event of an outage is limited by the ability of the distribution system to provide sufficient supply from an alternate source. In the event of a wide-spread area outage, for instance, it may only be possible to re-feed portions of the distribution system.

System designs that incorporate microgrid technology provide system operators with options to maintain service to customers, even when traditional supply options are limited. On normal "blue sky" days, load in the microgrid can be served by the traditional distribution system. In the event of loss of supply to the area, the system operator can disconnect or "island" the microgrid area, supplying load with local distributed energy resources.

Q. What are some of the other benefits that microgrids provide?

A. Microgrids create opportunities to increase the use of cost-effective clean energy technologies. For example, adding solar generation paired with battery energy storage to a microgrid enables the facility to provide additional resiliency benefit in addition to its other use cases. As a result, clean energy technologies used in microgrid applications are typically more cost effective than similar stand-alone facilities.

In addition, the resiliency improvements associated with microgrids result in additional economic and safety benefits. Economic costs associated with power outages can be substantial. This is particularly true for large research or industrial facilities that are not designed to handle sustained outages. Community microgrids that incorporate critical municipal loads have significant safety benefit by providing power to facilities such as police, fire and services such as wastewater treatment. Critical loads may also include facilities that can serve as shelters for local residents.

Q. Please provide an overview of the Company's proposed Oyster River Clean Innovation Project.

A. The Company, in collaboration with UNH and the Town of Durham, is proposing to develop a community multi-user microgrid to optimize the integration and dispatch of DER, improve resiliency, and provide environmental benefits all in a safe and secure manner. The proposed demonstration would group multiple customers on a designated portion of the electric system and provide power to them from existing local energy sources and newly installed local solar generation. A battery would also be installed on the system to provide "stored" electricity during a power interruption or when solar generation is not available.

Q. What is the scope of authorization that PSNH seeks in this case for the Oyster River Clean Innovation Project?

A. Similar to the Westmoreland Project described above, PSNH is requesting that the Commission review the Company's proposed Oyster River Clean Innovation Project ("Oyster River Project") in this case and pre-authorize the Company's capital expenditure related to this program, estimated at $15 million as well as incremental O&M expenditures related to the microgrid. The Company is not proposing to recover these amounts through the base rates that the Commission will set in this docket. Instead, the Company is requesting the Commission's approval of a separate rate mechanism through which recovery of costs for projects such as the Oyster River Project could take place.

Q. Why are demonstration projects important?

A. A demonstration project is an opportunity to deliver near terms benefits while also advancing the body of knowledge in the field of cutting-edge energy technologies—including solar and energy storage operated in a microgrid context—and to inform future deployments of such technologies.

Q. Why is the Company targeting UNH and critical infrastructure in the surrounding Town of Durham as the location for the proposed Oyster River Project.

A. Generally speaking, college campuses are excellent candidates for microgrid development because of the self-contained nature and the 24/7 energy needs. The Company will be able to leverage some of the existing infrastructure on the UNH campus for purposes of the demonstration project. The UNH campus currently has extensive infrastructure that supports reliable service to its buildings. The Oyster River Project will augment this infrastructure to further enhance the resiliency of the campus system. The Town of Durham has a relatively substantial proportion of critical load located in close proximity to the UNH campus that could be incorporated into the microgrid with limited impact to the existing electrical distribution system. Both UNH and the Town of Durham have demonstrated commitment to advancing clean energy objectives. UNH is home to the oldest endowed university sustainability program in the United States and the Town of Durham is actively pursuing opportunities to incorporate solar generation into its energy supply strategy.

Moreover, as a top-tier research institution, UNH will be able to leverage the microgrid demonstration project to conduct study into various microgrid technologies contributing to the knowledge base for a multi-user microgrid application. With the addition of solar generation and energy storage, the UNH campus and infrastructure in the surrounding Town of Durham will provide a unique research platform to investigate different aspects of the performance of a multi-user microgrid.

Q. Please describe the types of investments will be necessary to enable the Oyster River Project?

A. The Oyster River Project is expected to consist of the following five investment types:

- Energy storage will be used to help balance load and generation in the microgrid and support the inclusion of intermittent solar generation in the microgrid.
- Solar generation will be used to demonstrate the use of intermittent distributed energy resources in a resiliency application.
- Microgrid controller software technology will be used to control microgrid resources to balance load and generation in the island configuration.
- Limited additional distribution infrastructure will be required to electrically isolate load included in the microgrid.
- Communications infrastructure may be required to augment existing systems to ensure robust secure communications to and from resources in the microgrid.

Q. Why is PSNH including solar and energy storage as part of the Oyster River Project?

A. The Company proposes to include solar and energy storage to enhance the clean energy and greenhouse gas reduction benefits of the project. In addition, the Company is deploying these specific technologies together to better understand how battery storage can be used to optimize the operation of an intermittent generation resource like solar. For example, when solar generation is paired with battery storage, the battery can be used to provide stored power during the nighttime or on cloudy days when solar panels are not producing electricity.

Q. What is the current status of development for the Oyster River Project?

A. The Oyster River Project is in the early stages of development. The Company has established weekly meetings with UNH and executed a Memorandum of Understanding ("MOU") with UNH to govern the development of the project. The MOU is provided in Attachment GTEP-5. The Company has also had preliminary discussions with representatives from the Town of Durham and expects to continue the dialogue regarding the role of the town in this project.

Q. What is the proposed ownership model for the assets that will be developed as part of the proposed Oyster River Project?

A. The Company will own, operate, and maintain all the front-of-meter assets associated with the demonstration project including the solar generation, battery storage, any required distribution system upgrades, and the microgrid control infrastructure needed to ensure load and generation are balanced in an islanded configuration. In addition, to the extent that any additional advanced sensing and communications equipment is necessary, PSNH expects to own, operate and maintain those assets that are supported by customer rates.

Q. What is the current estimated cost for the Oyster River Project?

A. The Company's preliminary cost estimate for this project is in the range of approximately $15 million. This estimate reflects the early-stage of scoping and conceptual design that has been conducted for the Oyster River Project thus far. The Company will be conducting a more comprehensive analysis of this project and expects to have additional information on project scope, schedule and budget to provide to the Commission at a later stage of this proceeding.

Q. How does the Company plan on procuring the assets associated with the Oyster River Project?

A. PSNH will employ a competitive procurement process to secure all necessary services and physical assets that will be deployed in connection with this project to ensure that it is conducted on a cost-effective basis.

Q. Is PSNH planning to seek any external funding for the Oyster River Project?

A. Yes. The Company has developed a research statement and is preparing a proposal to seek external federal funding for this demonstration project. The Company is monitoring DOE grant and funding announcements for opportunities for which the Oyster River Project may be eligible. Any application for external federal funding would be contingent upon prior state regulatory approval of the demonstration project by the Commission. Should the Company be awarded any external federal funding, those funds would be used to offset the costs of the demonstration project.

Q. Is the Oyster River Project contingent upon receiving external funding?

A. The project is not contingent on receiving external funding. PSNH sees value in moving forward with this project, subject to Commission approval, because the customer benefits and learning opportunity from the project are important regardless of the availability of external federal funding.

Q. What are some of the areas that the Company would like to study as part of the proposed Oyster River Project?

A. PSNH is planning to study: (1) Advanced Sensor Networks; (2) Optimization and Control; and (3) Cybersecurity, in the context of the Oyster River Project. These specific areas of anticipated study are designed to add to the state's and the broader utility industry's knowledge base with respect to the deployment and operation of multi-user microgrids. As the demonstration project is further developed and refined, there may be additional areas of study that may be identified by the Company and its partners at UNH and the Town of Durham.

Q. Please provide more detail regarding the anticipated areas of study related to sensing networks and distributed control.

A. One key research objective would be to develop robust sensing and monitoring architectures that consider the latency constraints (i.e., the delay between when information is sent and when it is available at the other end of the communication system) in sensing and communication signals and unstable communication between neighboring energy sources and users.

In addition, achieving reliable and efficient operation of micro-grids can be challenging. Balancing customer load and generation on the relatively small scale of a microgrid means that both supply and demand are likely to be quite variable when intermittent DERs, such as solar energy, are used for energy generation. The imbalance between supply and demand can be mitigated by using energy storage, using diverse energy sources, and predicting and scaling demand. Accordingly, the Company expects to work collaboratively with UNH to evaluate ways in which tools and techniques can be employed to optimize supply and demand within the proposed microgrid demonstration project.

Q. Please provide more detail regarding the anticipated Cybersecurity area of study.

A. Cybersecurity is a critical component of smart grid and microgrid environment programs. In addition to utilizing the Company's robust and proven standard practices with respect to integrating technology securely onto its electric power system, the Company and UNH have identified opportunities to gain greater insight into the use of advanced sensing technologies for the purposes of adding additional threat detection capabilities. The timing of powering on additional sources or engaging storage facilities takes timing coordination. Phasor Measurement Units (PMUs) are modern approaches to monitor and stabilize the grid's power and utilize networking and time synchronization to perform distributed measurements. Time sensitive networking is a more recent entrant to assist in microgrids, assisting in improved control of such elements as inverters. Disruption of these networking systems can potentially result in false measurements leading to actions that have the potential to disrupt grid operations.

Q. Please describe the Company's proposed evaluation plan for the demonstration project.

A. PSNH expects to finalize the specific areas of study prior to commencement of the project as well as specific use cases, data gathering and measurement, and assumptions the Company is seeking to validate. The Company would file this initial scoping report with the Commission. To evaluate the technical and non-technical benefits of the demonstration project on an on-going basis, the Company expects to complete an annual report for each year of the demonstration project and to file these annual reports with the Commission. In addition, the Company would file a final report with the Commission upon completion of construction and when the demonstration project is in service.

Q. Will the Commission retain oversight of the Oyster River Project?

A. Yes. The Company recognizes that its efforts to develop and implement this microgrid demonstration project are at a beginning stage. Therefore, the Company will periodically provide progress reports to the Commission regarding the direction and progress of the Company's efforts in the preliminary design and engineering of the project. Also, as noted above, the Company will file annual reports with the Commission on its findings as well as a summary report at the end of the demonstration project. The Company will provide the Commission with further information on this project as it makes further progress on the preliminary design and engineering.

Q. Does this conclude your testimony?

A. Yes, it does.

Eversource Energy
PSNH Rate Filing
Westmoreland Energy Storage Project
Attachment – Photos of project area & locations

Westmoreland Fire Department

Eversource Energy
PSNH Rate Filing
Westmoreland Energy Storage Project
Attachment – Photos of project area & locations

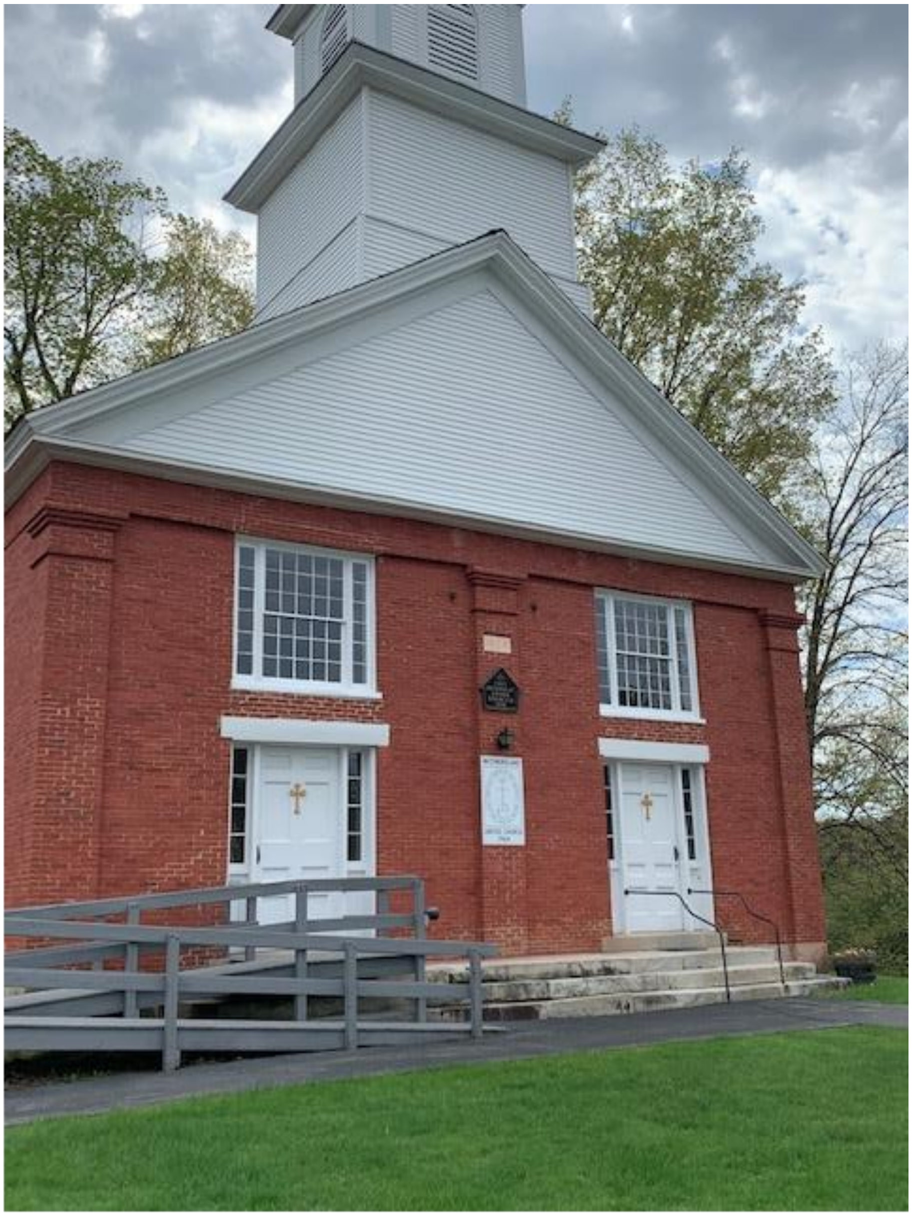
Westmoreland Town Hall – next to Fire Department

Eversource Energy
PSNH Rate Filing
Westmoreland Energy Storage Project
Attachment – Photos of project area & locations

Westmoreland Post Office – in Town Hall Building

Eversource Energy
PSNH Rate Filing
Westmoreland Energy Storage Project
Attachment – Photos of project area & locations

Community Church – across from Town Hall



Eversource Energy
PSNH Rate Filing
Westmoreland Energy Storage Project
Attachment – Photos of project area & locations

Westmoreland Village Store – next to Town Hall

Eversource Energy
PSNH Rate Filing
Westmoreland Energy Storage Project
Attachment – Photos of project area & locations

Consolidated Communications Building – near Village Store

Eversource Energy
PSNH Rate Filing
Westmoreland Energy Storage Project
Attachment – Photos of project area & locations

Westmoreland School – down the street from Town Hall, Village Store and Fire Department

Eversource NH
Estimates of Energy Efficiency Opportunity in Westmoreland

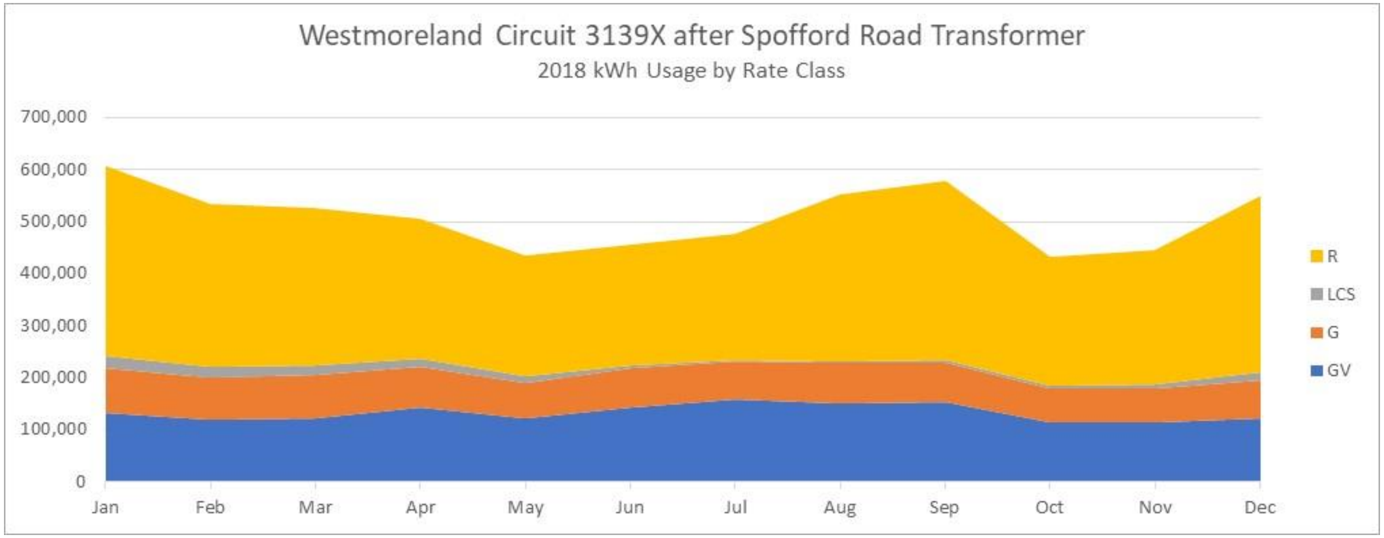
Westmoreland

3139X

EE Related Energy Efficiency

- NH RSA Section 374-F:4, below.
- (e) Targeted conservation, energy efficiency, and load management programs and incentives that are part of a strategy to minimize distribution costs may be included in the distribution charge or the system benefits charge, provided that system benefits charge funds are only used for customer-based energy efficiency measures, and such funding shall not exceed 10 percent of the energy efficiency portion of a utility's annual system benefits charge funds. A proposal for such use of system benefits charge funds shall be presented to the commission for approval. Any such approval shall initially be on a pilot program basis and the results of each pilot program proposal shall be subject to evaluation by the commission.

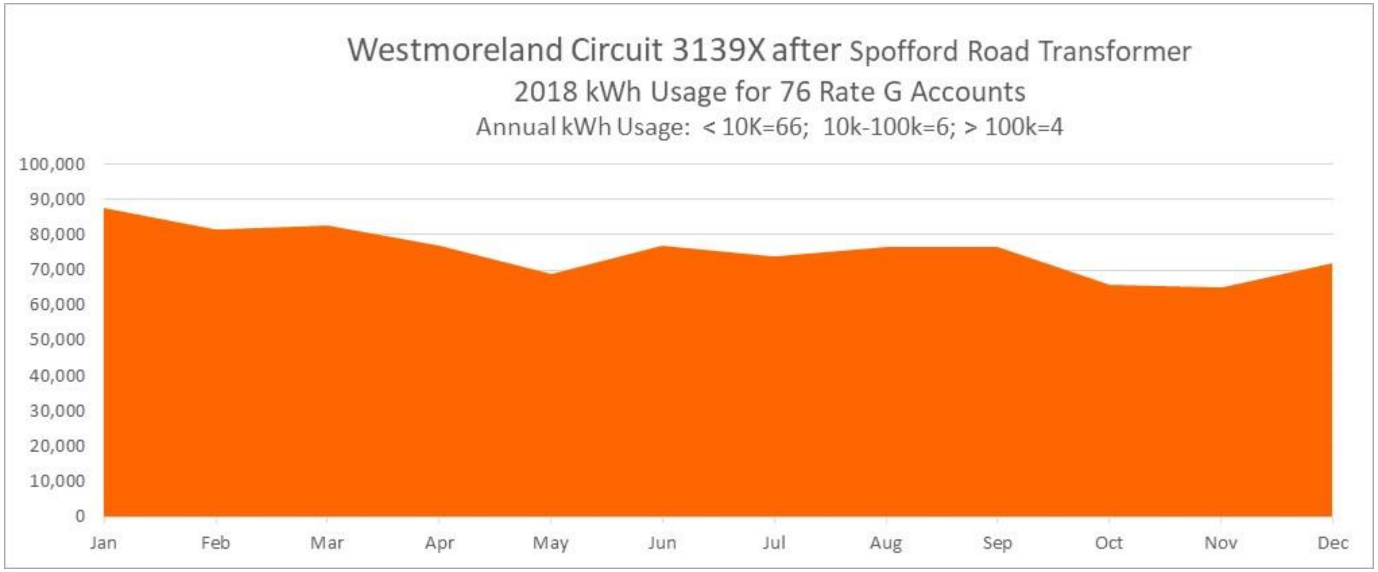
Stacked Usage



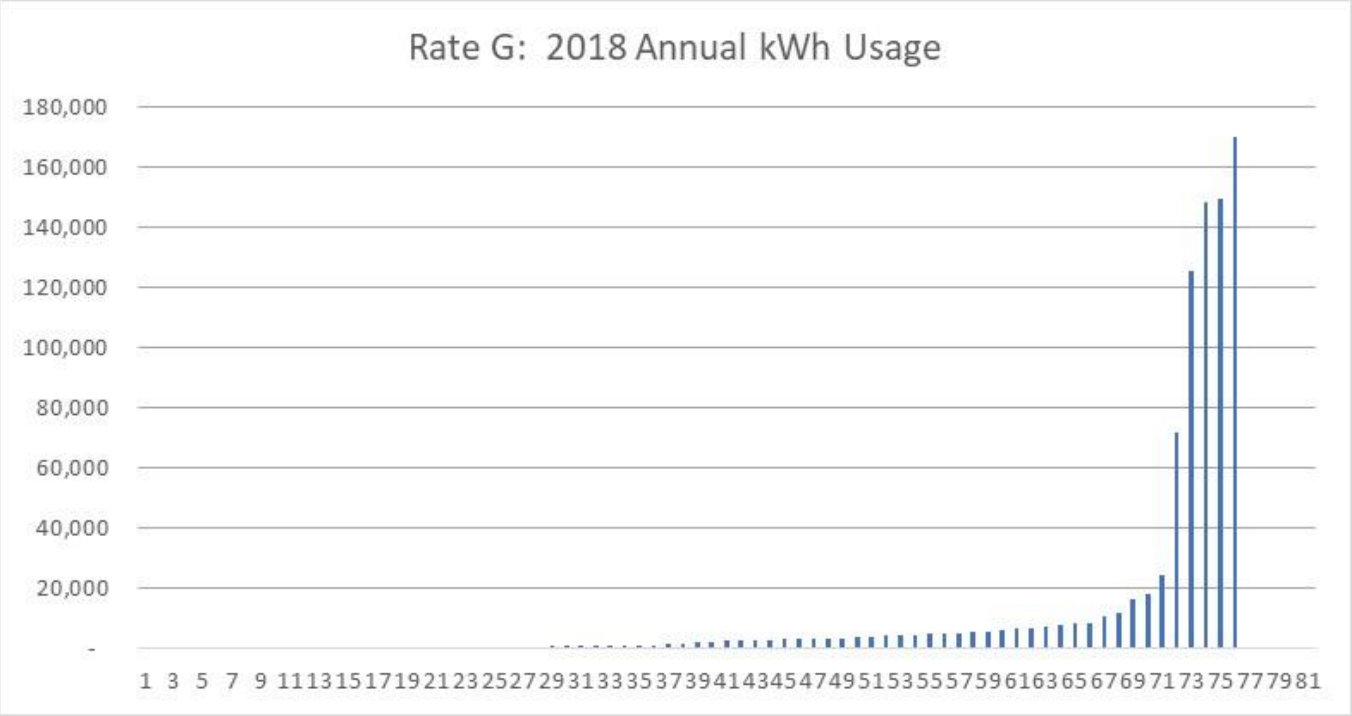
GV Account EE Opportunity

- There is one primary GV Account in Westmoreland
- This account is currently going through an expansion, which will increase usage.
- Energy efficiency staff are currently working with this account on potential EE projects.
- GV Account Estimated Participation = 1

G Accounts (< 100 kW)

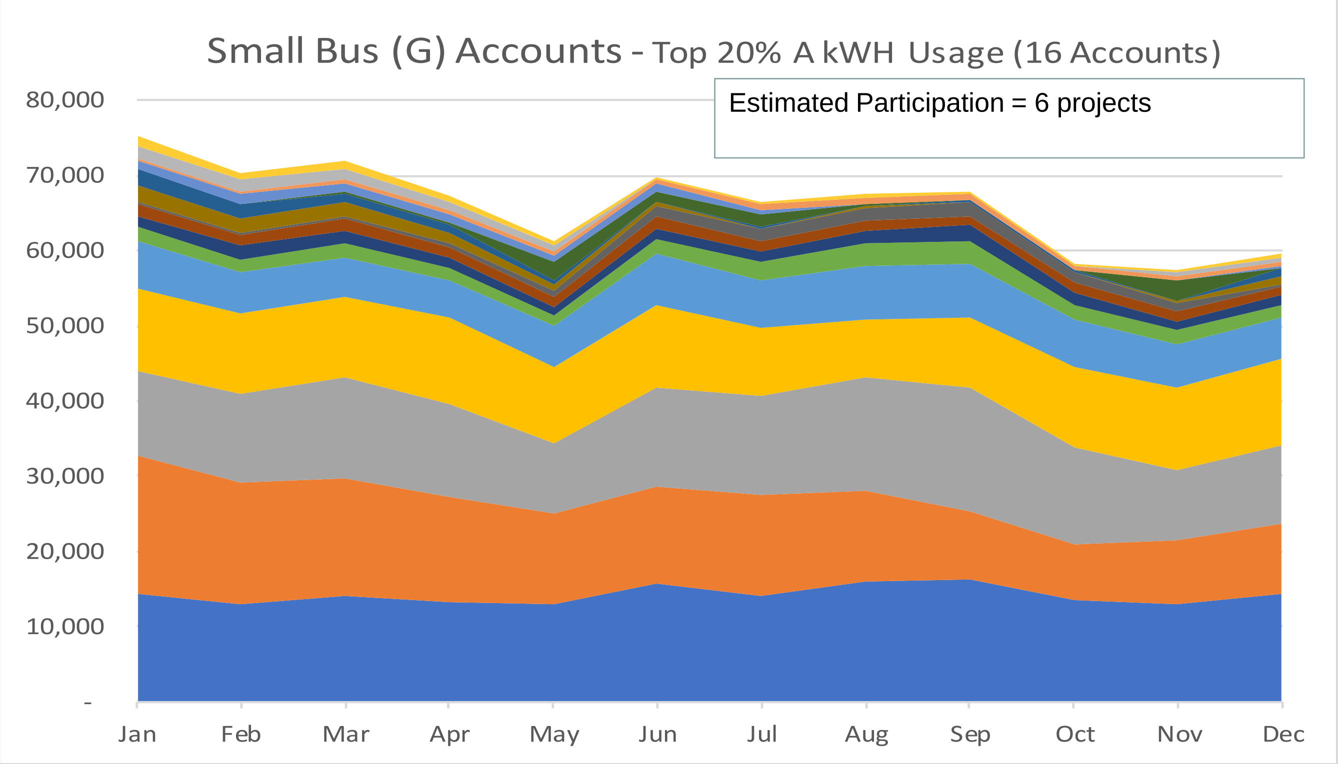


G Accounts (< 100 kW)

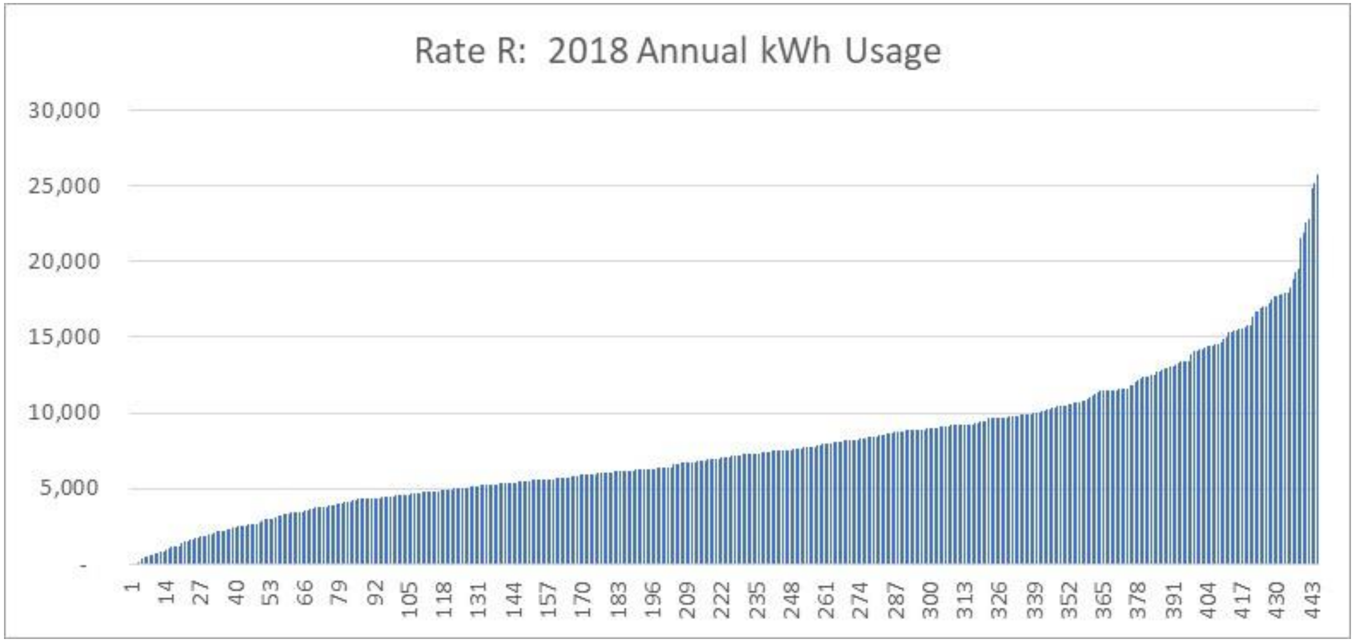


G Account EE Opportunity

EVERSOURCE ENERGY

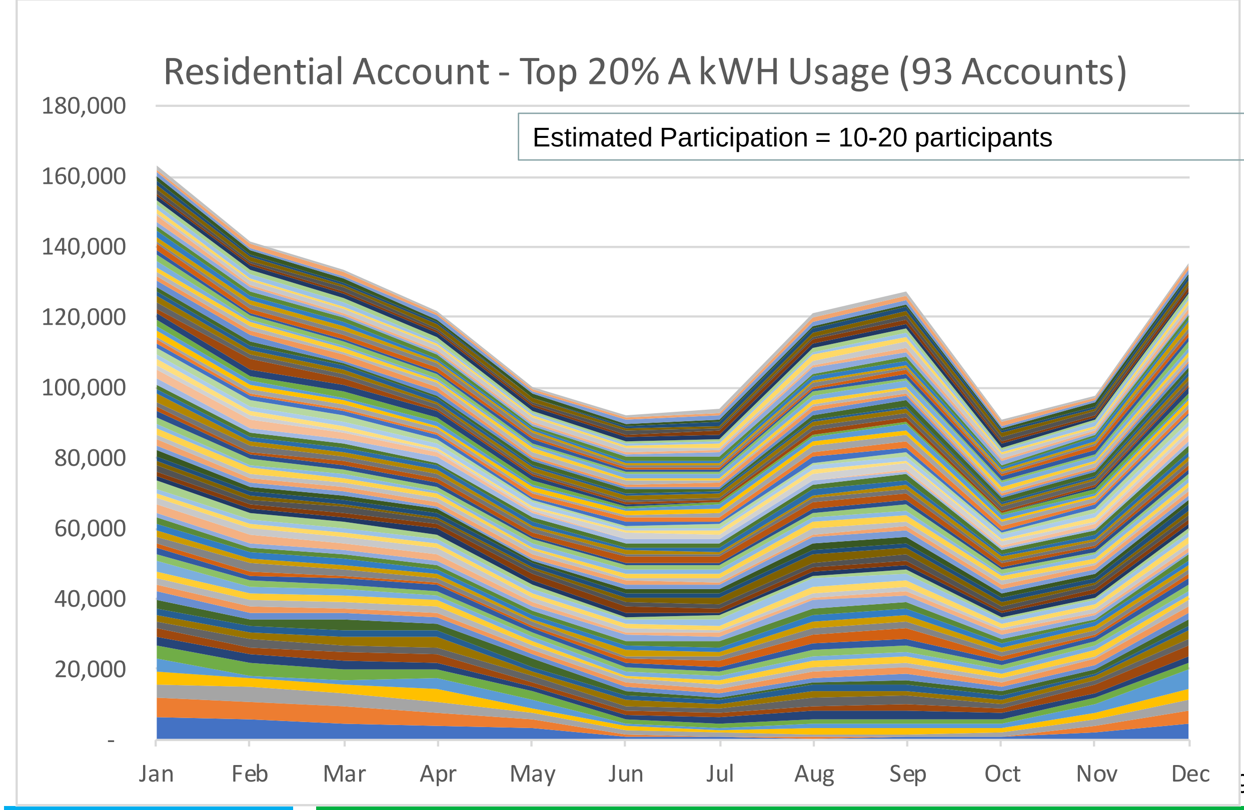


Residential Accounts (448)



Residential Account EE Opportunity

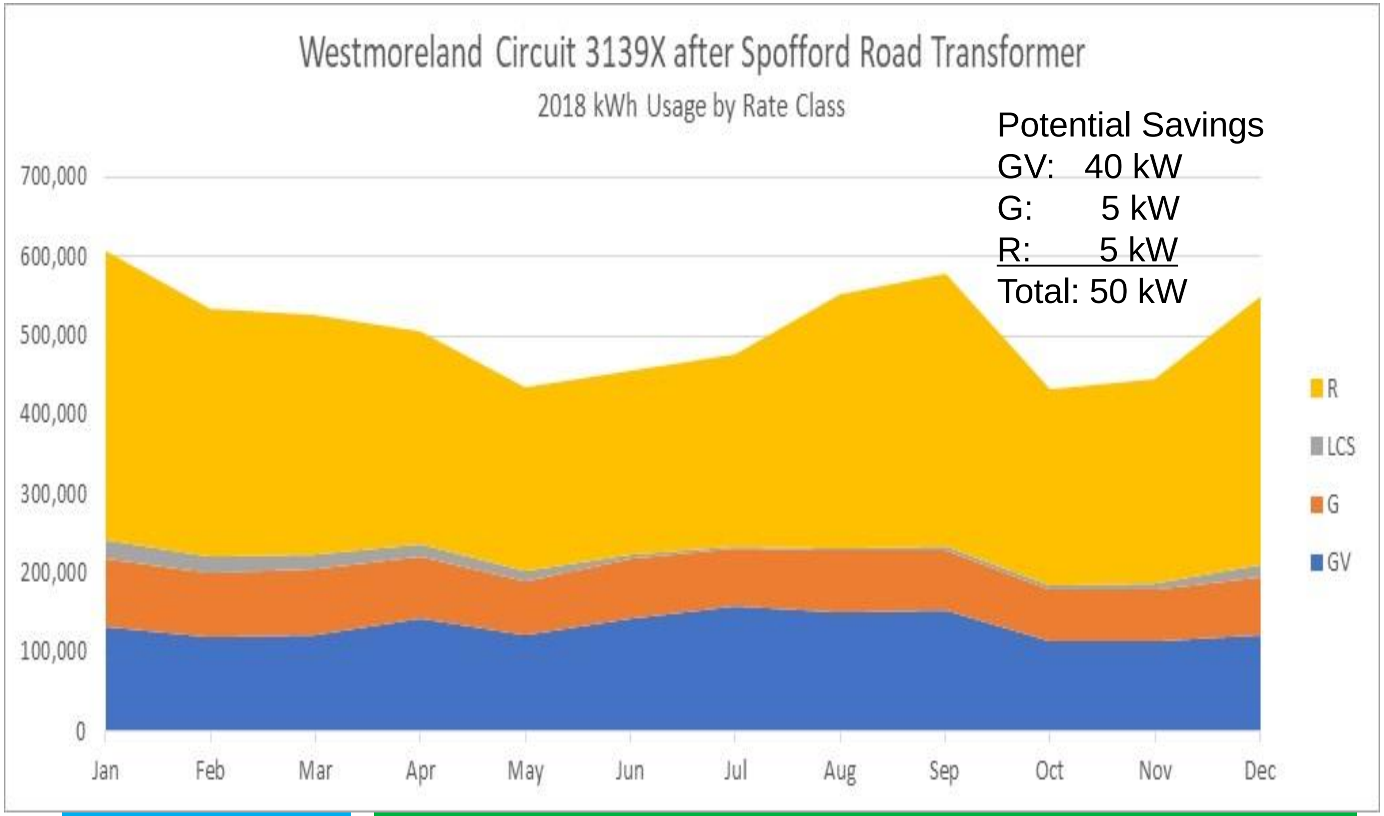
EVERSOURCE ENERGY



9

Stacked Usage (600,000/744= 806 kW)

EVERSOURCE ENERGY



Potential Savings
GV: 40 kW
G: 5 kW
R: 5 kW
Total: 50 kW

Residential Demand Response

Residential Demand Response

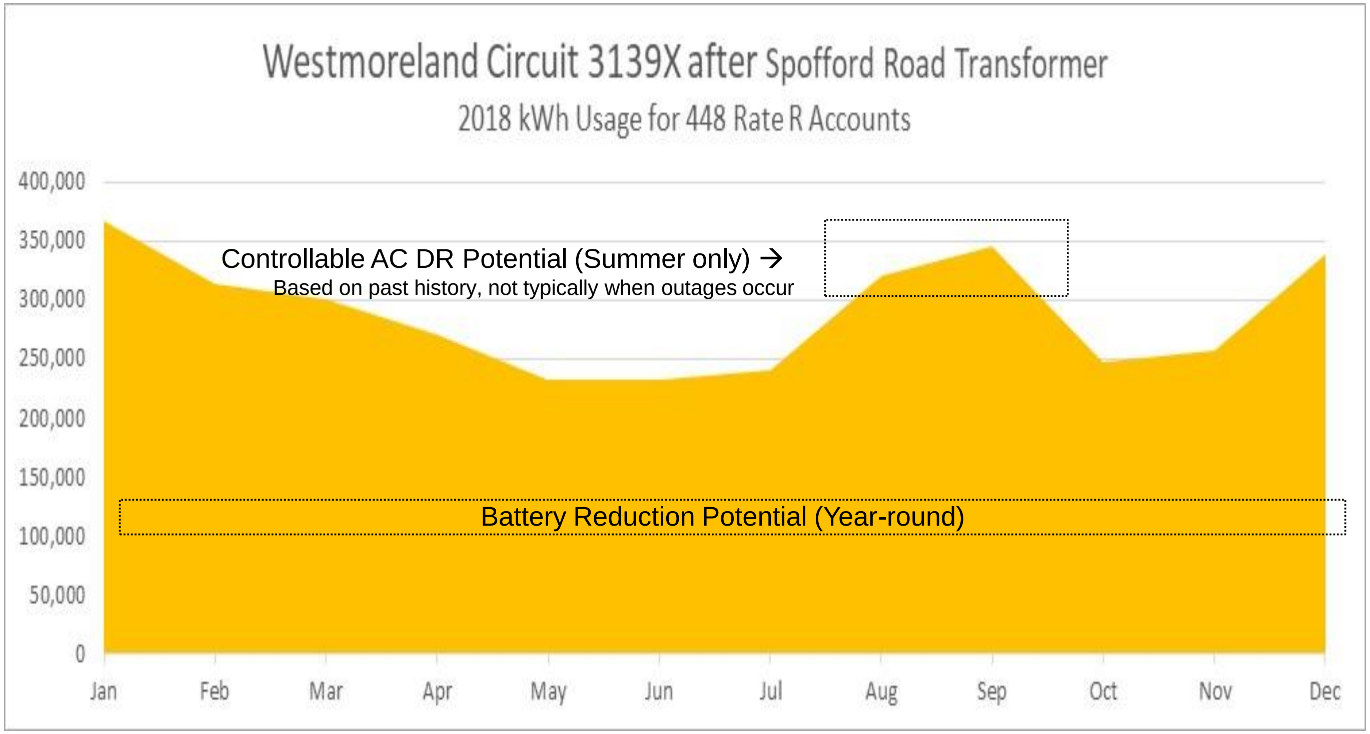
1. **Batteries**
   4-5 kW / Account
   Up to 10 on Circuit 3139x
   10 x 5 kW = 50 kW
   Year-round

2. **Controllable Air Conditioning**
   0.5 kW / Account
   Up to 30 on Circuit 3139x
   AC: 30 x 0.5 kW = 15 kW
   Summer only

Residential Accounts (of 448 Accounts)

EVERSOURCE ENERGY

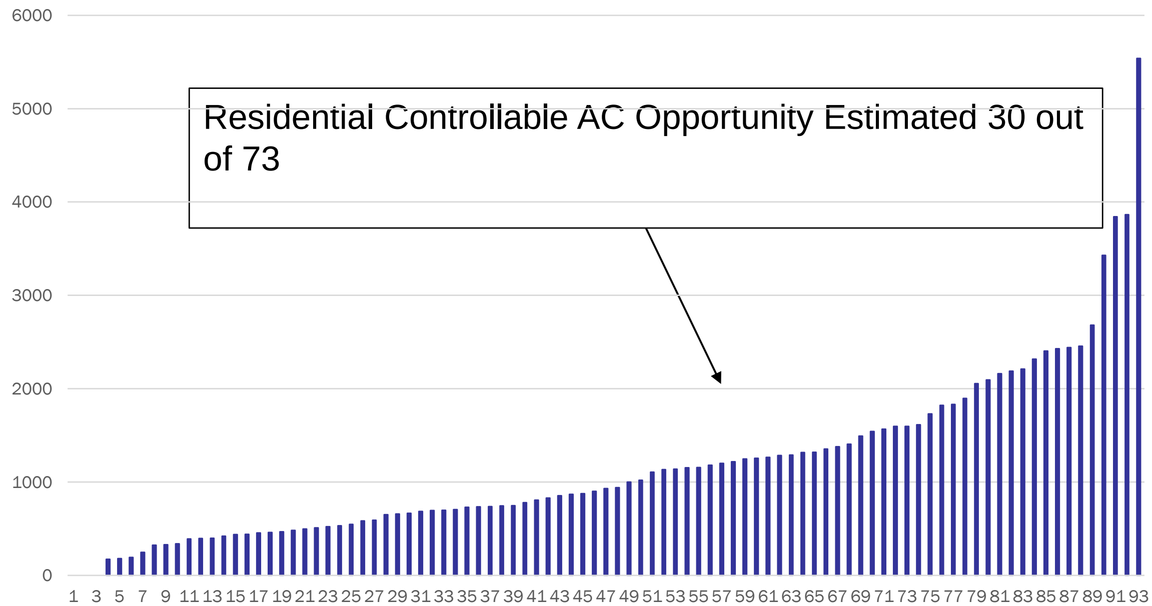
Batteries: up to 10 Homes
Controllable AC: up to 30 Homes



DR: 73 Customers with Estimated Cooling > 1,000 kWh during Summer

Residential Customers (20% high users)

73 Customers with Higher Summer Load kWH > 1,000 kWh



Westmoreland: Est. EE & DR Savings

EVERSOURCE ENERGY

1. Estimated Energy Efficiency

Customer Class	Qty	Est kW	When?
Large Business	1	40 kW	year-round
Small Business	6	5 kW	year-round
Residential	10-20	5 kW	winter
Total Est. Savings	17-27	**50 kW**	

2. Estimated Demand Reduction

Battery Storage	10	50 kW	year-round
Controllable AC	30	15 kW	summer
Total Est. Savings	40	**65 kW**	

Eversource Energy

Conceptual Design Report for Eversource Westmoreland Energy Storage System

May 2019

Doosan GridTech
71 Columbia St, Suite 300, Seattle, Washington, 98104

Section 1 Executive Summary

The Eversource engineering team reviewed its New Hampshire service territory for energy storage use cases that, combined with efficiency and demand response, could cost-effectively defer traditional solutions. Eversource commissioned Doosan GridTech to review and evaluate the feasibility of the leading storage component candidate on its selection matrix: the 3139X circuit in the area of Westmoreland, New Hampshire, which presents with significant reliability challenges. This feasibility study examines the 3139X electrical system, presents a conceptual design for an energy storage system (ESS), and assesses the benefits achievable through an ESS connected in Westmoreland.

The primary goals of the Westmoreland ESS are to improve reliability on an isolated and vulnerable section of the 3139X feeder, demonstrate the ability to provide value for customers through peak shaving and other ESS use cases, and develop best practices for the deployment and control of energy storage.

A 1.7MW / 7.1MWh lithium ion ESS is recommended to meet these goals.

a. The recommended primary use cases are islanding to improve distribution reliability and peak shaving to achieve Regional Network Service (RNS), Local Network Service (LNS) and ISO-NE capacity cost savings.
b. Lithium ion battery technology is recommended based on its technological maturity and suitability to perform the recommended use cases.
c. A 1.7MW/ 7.1MWh ESS is recommended as a cost-effective size that enables primary use cases. Detailed sizing analysis is documented in Section 5. A 1.7MW/7.1MWh system:
    i. supports all commercial and residential load downstream of the Spofford step transformers through all upstream outages up to 4 hours in duration based on projected load through 2028
    ii. achieves approximately $485K in average annual projected RNS, LNS, and ISO-NE capacity charge reduction through peak shaving

The analysis resulted in the following findings:

- The Westmoreland site is uniquely well-suited to use energy storage to cost-effectively defer traditional solutions to address reliability issues while also providing additional cost savings to customers by means of peak shaving.
    a. The section of the 3139X circuit downstream of the Spofford step transformers is a rural, radial feeder prone to outages.
    b. Critical loads in the town center of Westmoreland (an elementary school and town emergency shelter, a fire station, a nursing home, a town hall, a post office, and a communications building) are located on this radial section and currently cannot be served during loss of supply on 3139X upstream of the town center.
    c. An ESS located near the Westmoreland town center could island the 3139X circuit downstream of the Spofford step transformers and maintain service to residential and critical loads during upstream outages for up to 4 hours under peak conditions based on projected load through 2028.

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Docket No. DE 19-057

d. If existing or future sectionalizing switchgear lies between a fault on 3139X downstream of the Spofford step transformers and an ESS located near the Westmoreland town center, the ESS could maintain service to critical and residential loads downstream of the sectionalizing switchgear for more than 4 hours at peak load based on projected load through 2028.

- Several distinct ESS applications were studied and technical and economic benefits were quantified.
  a. The ESS will provide backup power to support the 3139X circuit downstream of the Spofford step transformers, improving reliability and maintaining service to customers and critical loads in the event of an upstream outage. A wires alternative would cost $6 million.

  b. The ESS will shave peak load on the 3139X circuit, reducing RNS, LNS and ISO-NE capacity charges for customers.
  The demonstration of peak shaving will allow Eversource staff to develop best practices for control and operations and ensure that future ESS deployed to defer capacity upgrades will be operated with high reliability and performance. More details on the peak shaving application can be found in Section 0

  c. The ESS will demonstrate primary frequency response. While currently provided by traditional generation, FERC Order 842 (Feb. 2018) requires all new interconnecting distributed energy resources to demonstrate capability of providing this service. This application is discussed further in Section 5.3.

- The costs and benefits of the recommended 1.7MW / 7.1MWh ESS are:

  a. The total capital cost of the ESS is $7.0M which includes a 20% contingency. This includes a fully loaded EPC project budget of $4.3M; the remainder is fully loaded direct expenditures by Eversource. Assumptions, cost breakdown, battery replacement plan, and more cost estimate details are discussed in Section 7.1.

Table 1-1: Total project budget estimate in $000s

Budget Elements		2020
Total EPC capital budget, fully loaded		$4,328
Eversource Direct Capital Expenditures (line items fully loaded)	Eversource staff labor including EE, PM, legal	$1,491
	Permitting	$176
	Systems Integration	$171
	Site Development and Building	$562
	Interconnection Switchgear, Aux Power Equipment, and Communication	$273
	Total Eversource direct spend, fully loaded	$2,674
Project Capital budget total, fully loaded		$7,002

b. The operating and maintenance cost of the ESS is given in Table 1-2. A detailed breakdown of the elements included in this estimate is provided in Section 7.1.3.

Table 1-2: Annual O+M Costs

Operating and Maintenance ($000)	
Average Annual Costs	$140

c. The quantifiable economic benefits associated with the Westmoreland ESS are shown in Table 1-3. The values in Table 1-3 for RNS and Capacity benefits assume that 10 of 12 monthly peaks are hit for RNS savings and the yearly Capacity peak is hit with the ESS. A detailed discussion of potential economic benefits and additional revenue scenarios can be found in Section 5.2.2.

Table 1-3: Benefit Summary

One-time Benefits	Value ($000)
Deferred Distribution Upgrades	$ 6,000
Annual Benefits	**Average Annual Value ($000/yr)**
RNS Charge Reduction	$ 348
ISO-NE Forward Capacity	$ 120
LNS Charge Reduction	$ 19

d. The following list provides a qualitative overview of the potential benefits realized through the Westmoreland ESS.

i. Improved customer power quality

ii. Improved customer reliability

iii. Development and demonstration of best practices for peak shaving when there is a power flow constraint in the system to maintain power quality or avoid equipment damage, and to reduce RNS and ISO-NE capacity costs

iv. Development and demonstration of best practices for primary frequency response

v. Experience in designing, deploying, operating, and maintaining a utility-scale, utility-owned and -operated ESS

vi. Help demonstrating and articulating the value of grid-side enhancements and assisting in increased transparency with customers and other stakeholders

vii. Integration of a new distributed asset type into the Eversource New Hampshire control and operations software

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Section 2 Background

Energy storage has unique flexibility through its ability to serve as generation or load and to produce or absorb both real and reactive power. ESS can be used to address the full range of real and reactive power needs, performing discrete grid services at the generation, transmission and distribution levels of the electricity system.

The challenge of this flexibility and range comes in two areas: 1) determining the most valuable use of the ESS resource at each moment of each day; and 2) developing new organizational control and communication practices that may require the coordination of groups that have historically operated independently.

Grid-scale, utility-integrated energy storage is a relatively new technology for electric utilities. For ESS to serve as multi-purpose grid management tools requires energy systems to be tightly integrated with distribution operations. Energy storage controls need to perform multiple, simultaneous tasks:

-dispatch both real and reactive power;
-factoring in local circuit conditions and bulk power system opportunities;
-coordinating with the DSCADA software that controls the overall distribution system.

These challenges are best addressed through the deployment of demonstration projects and the development of best practices around energy storage application prioritization and control.

Eversource has engaged Doosan GridTech to provide a conceptual design report that evaluates the feasibility of using an ESS to provide customer reliability benefits, manage the impacts of DERs and support the integration of additional DER, along with a quantitative analysis of the benefits and costs over the project's life. The design study evaluates technical feasibility and determines an optimal strategy of deployment.

Doosan's power systems integration team has years of experience providing storage system engineering and conceptual design work to utilities across the country. Doosan has worked closely with Eversource to determine the optimal ESS deployment strategy and to quantitatively analyze benefits and costs. This work has been performed with an eye towards scalability and setting processes and strategies in place that can inform future expansion of Eversource's storage fleet to cost-effectively bring value to customers.

Section 3 Goals and Objectives

The following goals and objectives have been identified for the Westmoreland ESS demonstration project:

3.1 GENERAL: Eversource ESS Projects and ESS Scalability

1. Safely install, operate, and maintain a utility-scale ESS within Eversource's New Hampshire service territory.
2. Provide an ESS control and monitoring capability that can be managed by the appropriate local field operations personnel as well as the regional bulk power control center with minimum impact on the day-to-day operations of other operational entities within Eversource.
3. Demonstrate and evaluate metrics and techniques that enhance Eversource's ability to design and model the appropriate ESS capacities (energy and power) in future ESS deployment efforts.

4. Demonstrate and evaluate the benefits of open standards, including the Modular Energy Storage Architecture (MESA), in enhancing the scalability of energy storage integration with utility operations.[2]
5. Utilize field measurements from demonstrated ESS performance to quantify technical and economic benefits of each individual ESS use case as well as the sum of combined use cases.

3.2 GENERAL: Design study

1. Conduct an energy storage design process that engages and educates the Eversource engineering team and results in an approved ESS design that is compliant with Eversource engineering standards.
2. Design and demonstrate a control and dispatch architecture that achieves the maximum value for an ESS/ESS fleet by:
    a. Optimally blending distribution and bulk system applications to meet local circuit reliability and power quality goals while capturing value from bulk system applications
    b. Implementing the necessary interfaces with existing Eversource distribution and transmission control platforms to make ESS optimization decisions across multiple potential applications
    c. Executing autonomous ESS dispatch while also providing awareness and control to Eversource operators
3. Calculate project budget, costs and benefits, schedule, system design, and risk assessment to evaluate the value of an ESS facility to customers. Provide quantitative analysis to support Eversource's proposal to their regulators.

3.3 ESS VALUE: Westmoreland

1. Deploy utility-scale, utility-owned and -operated ESS to enhance customer reliability and reduce peaks.
2. Help demonstrate and articulate the value of grid-side enhancements and assist in increased transparency with customers and other stakeholders.
3. Identify and understand technical aspects of ESS integration and impacts on system planning, design, and operations.
4. Provide clear economic benefit to customers.
5. Support the development of the broader electric power system in a clean energy future by widespread dissemination of the findings of the demonstration project, by sharing a summary of performance data annually with regulators, the public, and other stakeholders.

Section 4 Site Selection and Westmoreland Electrical System

Westmoreland was selected as one of the best sites for an energy storage demonstration project by a cross-functional team at Eversource after a process that compared multiple candidate locations across a range of criteria. The site selection process is summarized in Section 4.1 and the Westmoreland electric distribution system is described in Section 4.2.

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[2] http://mesastandards.org/

4.1 Site selection

The site selection process resulted in the selection of one of the best locations for demonstrating energy storage. A cross-functional team at Eversource generated a prioritized list of benefits that could be realized by an energy storage system, including DER integration, the possibility of multiple stackable benefits, ability to defer equipment upgrade expenditures, capability to provide backup power, and practical deployment considerations such as the availability of land and complexity of site preparation. Eversource created a locational decision matrix comparing potential New Hampshire ESS host distribution substations in each of these categories. Table 4-1 lists scoring criteria for each benefit category and includes the scale used to score each substation in each category.

Table 4-1: Locational decision matrix categories and scoring

1 = Low	2 = Acceptable	3 = Average	4 = Promising	5 = Excellent
DER Penetration: The more DER equipment connected on the feeder, the higher the point value.				
Stackable Benefits: The more benefits that can be stacked (DER Integration, Load shifting, Load smoothing, Voltage Regulation, Frequency regulation, etc.), the higher the point value. Feeders were examined to analyze specific problems that can be addressed/studied.				
Avoid / Defer System Upgrades: The closer the existing equipment is to its maximum rating, the higher the point value. The highest value between feeder loading and substation loading was chosen.				
Backup Capability: The capability of a load zone to have various forms of redundancy received a higher point value. The more deficiencies and lack of redundancy the higher the point value.				
Land Available / Site Prep: Point value based on amount of Company -owned land and how readily available and cleared it is.				

Table 4-2 shows the locational decision matrix for New Hampshire distribution substations. The scoring categories are weighted according to Eversource priorities for ESS demonstration in New Hampshire.

Table 4-2: Locational decision matrix for NH substations

Substation	DER Penetration		Stackable Benefits		Avoid / Defer System Upgrades		Backup Capability		Land Available, Site Prep		Total	
	Weighting		Weighting		Weighting		Weighting		Weighting			
	10%		25%		25%		35%		5%			
	SCORE	Weighted Score	SCORE	Weighted Score	SCORE	Weighted Score	SCORE	Weighted Score	SCORE	Weighted Score	Total (out of 5)	Rank
Chestnut Hill 3139X	1	0.1	5	1.25	4	1	4	1.4	5	0.25	4	1
Peterboro 313	1	0.1	4	1	5	1.25	3	1.05	3	0.15	3.55	2
Greenville 3155	1	0.1	4	1	5	1.25	3	1.05	2	0.1	3.5	3
Hanover Street 16W3	1	0.1	4	1	5	1.25	2	0.7	5	0.25	3.3	4
Mont Vernon 24X1	1	0.1	3	0.75	3	0.75	4	1.4	3	0.15	3.15	5
Errol 3525X5	1	0.1	3	0.75	4	1	3	1.05	5	0.25	3.15	5
Brentwood 3103	1	0.1	2	0.5	4	1	4	1.4	2	0.1	3.1	7
Pittsfield 319	1	0.1	3	0.75	4	1	3	1.05	2	0.1	3	8
Tuftonboro 346	1	0.1	3	0.75	5	1.25	2	0.7	2	0.1	2.9	9
Pittsburg 355X10	1	0.1	2	0.5	2	0.5	4	1.4	4	0.2	2.7	10
New London 316	1	0.1	2	0.5	3	0.75	2	0.7	2	0.1	2.15	11

The Chestnut Hill substation has the highest total score and was selected as the best location for an ESS demonstration project in New Hampshire. The 3139X circuit in the Westmoreland area commonly appears on lists of circuits with worst reliability in Eversource's New Hampshire service territory. The circuit loading downstream of the Spofford step transformers is well-suited to the ESS size and cost range Eversource is considering for this demonstration project. More details on the 3139X circuit and Westmoreland electrical system are provided in Section 4.2.

Doosan GridTech has advised other utilities in the process of screening a list of candidate sites and selecting the best site to meet objectives. The process that Eversource used to select the Chestnut Hill substation and 3139X circuit is similar to the process that Doosan would have recommended.

4.2 Westmoreland electrical system

Figure 4-1 presents a simplified one-line diagram of the 3139X circuit annotated with information on distribution of critical loads, sectionalizing switchgear, circuit distance, and more.

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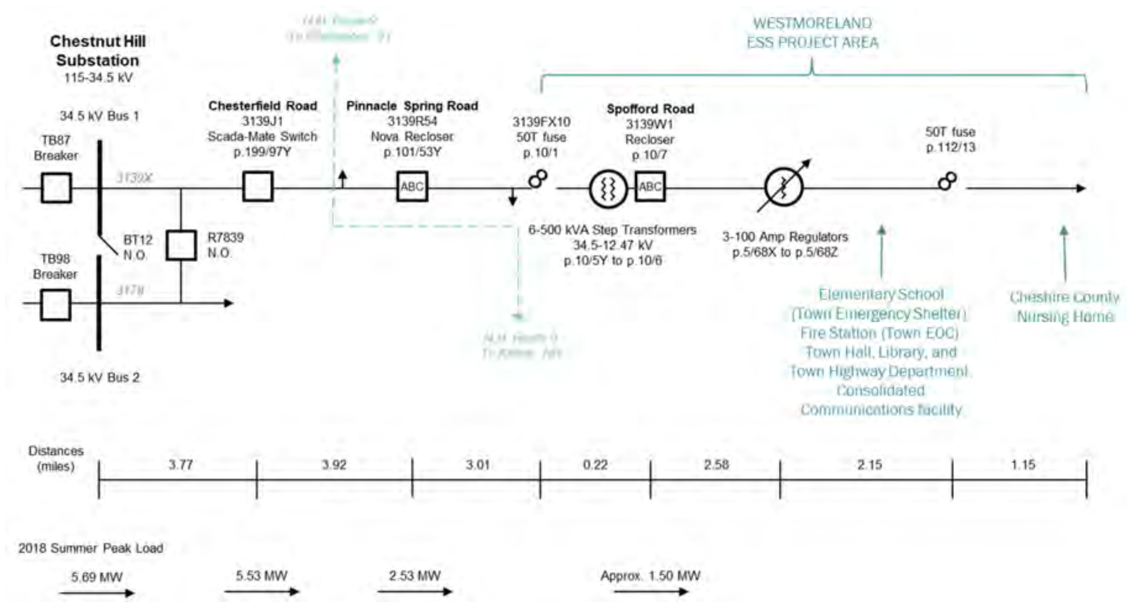

Figure 4-1: Annotated diagram of electrical system in Westmoreland environs

The Chestnut Hill substation serves the 3139X and 3178X circuits. 3139X is a radial 34.5kV feeder upstream of the Spofford Road transformers, which step voltage down from 34.5kV to 12.47kV. 3139X serves a load mix that consists primarily of rural residential loads with scattered light commercial loads.

The Westmoreland town center is located roughly 14 circuit miles of radial feeder from the Chestnut Hill substation and hosts critical loads including an elementary school (that serves as the town emergency shelter), the town fire station, Town Hall, the post office, a general store, and a Consolidated Communications building. The Cheshire County Nursing Home is located an additional 2 circuit miles downstream of the town center. Service to these critical loads is currently dropped during outages in the upstream distribution system and there are no alternate sources available through system reconfiguration today (see Section 5.1.2 for information on potential $6M circuit tie that would allow reconfiguration).

Table 4-3 lists the outages in the distribution system upstream of the Spofford step transformers that have caused loss of service to critical loads in the Westmoreland town center since 2012. There have been 13 such outages since November 2012 and these outages have an average duration of 2.2 hours and a maximum duration of 6.87 hours. Energy storage located in the Westmoreland town center can serve loads downstream of the Spofford step transformers during outages of this type.

Table 4-3: Outages in the upstream distribution system since 2012 that resulted in complete loss of service downstream of the Spofford Rd. step transformers

Date	Duration (hrs)
5/7/2018	0.32
4/4/2018	4.53
2/21/2018	0.97
12/12/2017	1.02
10/24/2017	0.67
10/27/2016	0.87
6/12/2016	2.83
11/27/2014	6.87
11/26/2014	1.78
3/22/2014	4.50
9/12/2013	1.40
6/28/2013	2.08
11/8/2012	1.15

Table 4-4 lists all outages on line 3139X downstream of the Spofford step transformers since 2012. There have been 24 such outages since November 2012 and these outages have an average duration of 2.8 hours and a maximum duration of 8.68 hours. Energy storage can serve some load downstream of the Spofford Rd. step transformers during outages of this type, depending on the location of the outage and sectionalizing switchgear. If the outage occurs upstream of the ESS and there is sectionalizing switchgear between the ESS and the outage location, then the ESS can form an electrical island and support loads downstream of the switchgear. If there is no sectionalizing switchgear between the outage location and the ESS, or the outage occurs downstream of the ESS, the ESS will not be able to perform islanding.

Table 4-4: 3139X outages downstream of the Spofford Rd. step transformers since 2012

Date	Duration (hrs)
7/25/2018	0.47
7/25/2018	1.53
6/18/2018	8.07
5/5/2018	0.55
12/23/2017	2.40
12/23/2017	6.73
12/12/2017	5.82
12/12/2017	4.82
12/12/2017	8.68
9/5/2017	6.22
9/5/2017	3.22
8/6/2017	2.93
8/6/2017	0.57
1/19/2017	2.23
1/19/2017	1.08
11/15/2016	0.87
6/14/2015	1.03
6/8/2015	1.82
6/8/2015	1.37
5/27/2015	1.50
11/2/2014	0.45
7/4/2014	2.98
10/6/2013	0.87
5/25/2013	1.97

While energy storage is capable of supplying power to critical Westmoreland loads during all outages of the type listed in Table 4-3 and some of the outages listed in Table 4-4, ESS ability to support an electrical island that includes all loads downstream of the Spofford step transformers throughout expected outage durations is dependent on ESS power and energy capacity. Outages downstream of the Spofford step transformers frequently occur in bunches during a single storm event. If long outages fall within a few hours of each other during a high-load period, the ESS recharge capability may be limited. ESS sizing analysis is detailed in Section 5.

Section 5 Valuation and Sizing Analysis

This section discusses sizing considerations and value streams associated with the primary use cases identified for the Westmoreland ESS.

5.1 Islanding

During loss of service in the upstream distribution system, an ESS can provide backup power to support an electrical island encompassing circuit 3139X downstream of the Spofford step transformers. The sizing goal for this use case is to set ESS power and energy capacities capable of supporting all load downstream of the Spofford step transformers through expected outage durations assuming 2028 projected load.

5.1.1 Islanding sizing methodology

ESS sizing for the islanding use case is based on the expected load profile of the electrical island and the target outage ride through duration. The electrical island in this case is the section of circuit 3139X downstream from the Spofford step transformers.

Load at the Spofford step transformers is measured manually at irregular intervals. Since no regular load metering occurs, the load profile of the electrical island must be estimated. Manual measurements show that load at the Spofford step transformers averages 27% of the total 3139X load. To account for load growth on the 3139X circuit, 2016 load data was scaled to projected 2028 values. Projected 2028 peak load at the Chestnut Hill substation (16.8MVA) is 112% of the measured 2016 peak (15.0MVA). Therefore, the equation used to estimate projected 2028 load at the Spofford step transformers is:

*Projected 2028 Spofford xfrmr load = 2016 3139X load * 0.27 * 1.12*

Figure 5-1 shows the resulting 2028 projected load profile at the Spofford step transformers. The average projected load is 1.0 MVA and the projected peak load is 1.7 MVA.

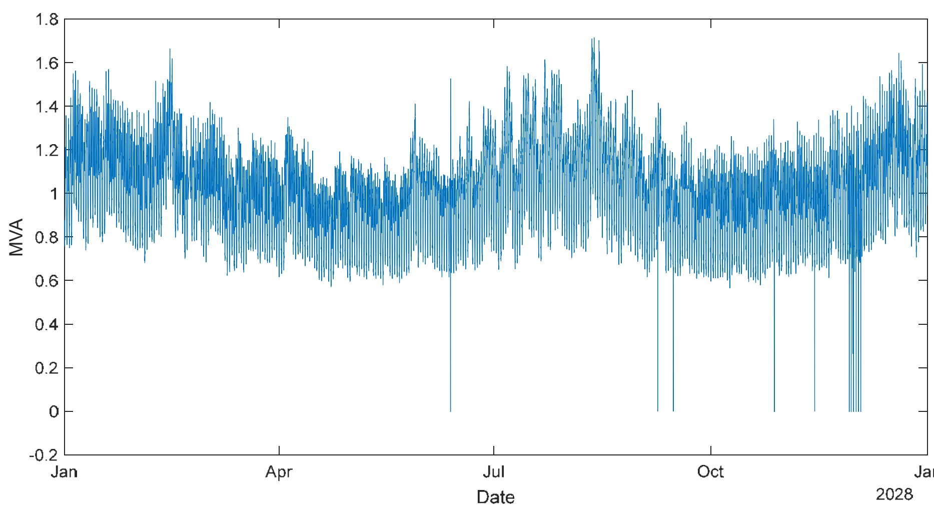

Figure 5-1: Projected 2028 load at the Spofford step transformers

The ESS power capacity necessary to support the electrical island during all possible outages is the island's peak load. Therefore, the recommended Westmoreland ESS power capacity is 1.7MW.

The ESS energy capacity necessary to ride through an outage is the area under the load profile curve over the duration of the outage. As an example, Figure 5-2 shows the projected 2028 load profile during an illustrative summer day. The shaded region shows the energy required to support projected load on 3139X during a 4-hour outage beginning at 4:30 P.M.

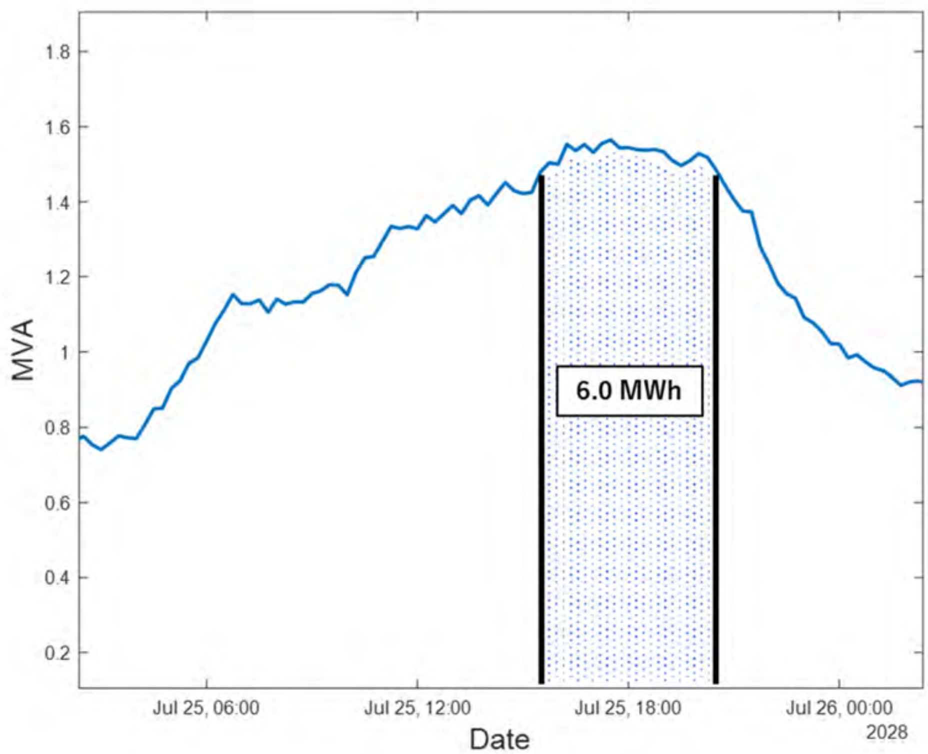

Figure 5-2: Illustrative 4-hour outage energy requirement

A comprehensive survey to determine the energy capacity required to ride through any outage of a certain duration can be carried out by evaluating outages starting at each 15-minute interval of the year. Figure 5-3 illustrates the power and energy requirements necessary to maintain service to line 3139X downstream from the Spofford step transformers during all potential 2-hour, 4-hour, and 7-hour outages, assuming the 2028 projected load profile. Each data point in Figure 5-3 represents the power and energy capacity necessary to ride through one simulated outage of the color-corresponding duration.

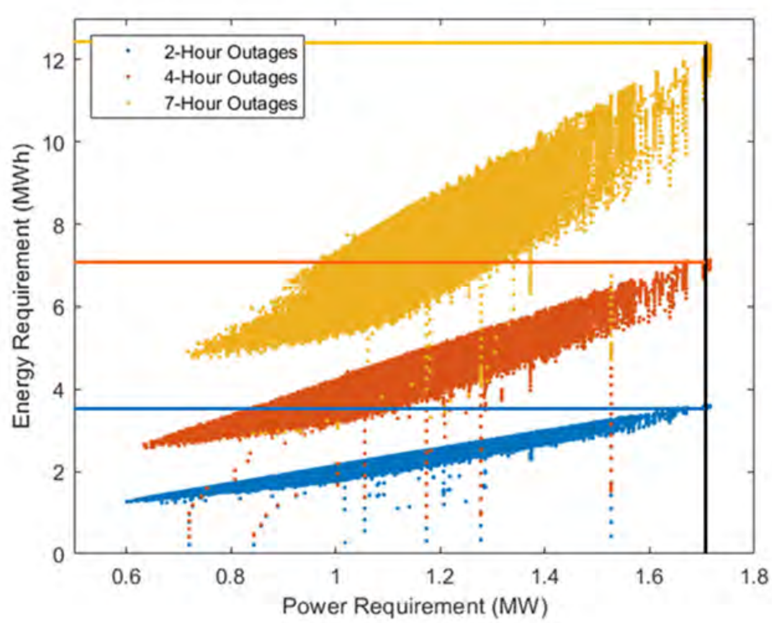

Figure 5-3: ESS power and energy requirements for simulated outages of different durations

The maximum power requirement for each duration is 1.7 MW, as this value is set by the annual peak load. The colored horizontal bars on the figure note the maximum energy requirement for each duration. The energy capacity required to maintain service to the electrical island throughout all 2-hour outages is 3.6 MWh, the energy capacity required to ride through all 4-hour outages is 7.1 MWh, and the energy capacity required to ride through all 7-hour outages is 12.4 MWh.

2-, 4-, and 7-hour durations were selected for this analysis based on historical outage durations recorded on the 3139X circuit. Outages experienced on the circuit since 2012 are listed in Section 4.2. Section 4.2 lists two types of outages: outages upstream of the Spofford step transformers that caused loss of service to the entire prospective electrical island and outages that occur downstream of the Spofford step transformers, within the prospective island. The primary focus for ESS sizing is the first of these types, as the ESS will be able to perform islanding during any of these outages. These outages average 2.2 hours and have a maximum duration of 6.9 hours.

2 hours was selected to illustrate average outage duration, 7 hours was selected to illustrate the maximum historical outage duration, and 4 hours was selected as a recommended target ride through duration, as 77% of historical outages on 3139X upstream of the Spofford step transformers have been 4 hours or shorter while the energy requirement reduction relative to the 7-hour outage energy requirement leads to significant system cost savings.

While a 12.4 MWh system is necessary to ride through any outage of the 7-hour maximum recorded historical outage duration, the recommended energy capacity is the 7.1 MWh necessary to ride through any 4-hour outage. The modest increase in potential outage ride through capability provided by the 12.4 MWh system is outweighed by the significant additional battery module cost.

5.1.2 Traditional alternative

To estimate the economic value that an ESS could provide through islanding, it is compared to traditional alternatives. Eversource engineers developed an alternative distribution solution to provide backup power to line 3139X downstream of the Spofford step transformers. This solution involves serving this portion of 3139X from the Emerald Street substation in Keene, NH via 10 miles of new spacer cable.

The estimated cost of this solution is $500,000 per mile with a 20% contingency, for a total cost of $6M.

The alternative solution would not have the duration restrictions inherent in a battery. However, the alternative solution would be vulnerable to storm-related outages and thus not be available at all times.

5.2 Peak shaving

5.2.1 Peak shaving for distribution system flexibility and reliability

The application of peak shaving may be valuable for a utility when there is a power flow constraint in the system to maintain power quality or avoid equipment damage, and it would be costly to upgrade equipment to remove the constraint. For example, when a distribution substation transformer nears its loading limit during high-load periods and load growth indicates that it will be necessary to replace the transformer with a higher-rated model before the end of its natural life.

An ESS connected such that by discharging the net load at the point of constraint is lowered can help to defer the transformer replacement. The same application may be applied to avoid upgrades to transformers, switchgear, or cables. To use an ESS for this purpose, a utility must have a very high degree of confidence in the availability and performance of the ESS, as well as practiced and high-functioning operational processes that ensure the ESS state of charge is managed to perform as needed, since failure to do so could result in equipment damage or loss of load. There are no existing constraints that require peak shaving to defer equipment upgrades on the 3139X circuit, but the Westmoreland ESS allows Eversource the opportunity to demonstrate and develop best peak shaving practices.

5.2.2 Peak shaving for RNS, LNS, and ISO-NE Capacity cost reduction

Peak shaving also has the potential to lower transmission and capacity costs, particularly by reducing costs on Regional Network Service (RNS), Local Network Service (LNS), and the ISO-NE capacity market. RNS charges are paid by transmission customers to transmission owners (ISO-NE Schedule 9) for transmission services and to the ISO (ISO-NE Schedule 1) for scheduling the movement of power through, out of, within and into the New England Control Area. RNS charges are calculated as the product of a transmission customer's Monthly Regional Network Load value (the hourly transmission customer network load coincident with the monthly system-wide peak load) and annually set Schedule 1 and Schedule 9 RNS rates. RNS rates have risen in recent years and 2018 ISO-NE Capacity, Energy, Loads, and Transmission (CELT) Report total RNS rate forecasts for 2019-2022 are provided in Table 5-1.

Table 5-1: ISO-NE RNS rate forecast

Year	Total RNS Rate ($/kW-yr)
2019	117
2020	123
2021	129
2022	135

Discharging an ESS during monthly network peak load hours will reduce RNS charges and result in customer savings.

This remainder of Section 5.2.2 is comprised of language provided by Eversource assessing RNS charge reduction and ISO-NE capacity savings opportunities:

Eversource has evaluated using generation, lithium-ion battery storage, and load controlled devices with a nameplate capacity of 5 MW or less for peak load reduction. This means that the assets will be called to put energy back onto the grid at peak times. Targeted peaks will include the monthly peaks used to determine RNS charges and the yearly summer peak that determines the ISO New England capacity supply obligation ("ISO Capacity") for load serving entities (LSE) serving our customers.

5.2.2.1 Using These Assets as Load Reducers Generally

Using generators as load reducers simply entails counting the generators' output as an offset to monthly or summer peaks instead of bidding the output into the wholesale market as a Settlement Only Generator ("SOG") and taking the market clearing price as compensation.

Using dispatchable batteries and controlled devices involves a similar practice. It is reasonable to expect that the company would need to discharge these assets several times per month, on average, to ensure that it hits the hours that will lower our system loads during monthly peak hours. In addition, the shape of the assumed peaks may require the assets to discharge for up to four hours during each peak shaving attempt to have reasonable confidence of lowering the monthly peak and not just shifting it to a nearby hour. Eversource expects that, through effective forecasting and deployment, it will be able to reduce our annual ISO-NE Forward Capacity Market coincident peak, which is the maximum hourly load on the ISO-NE system each year, and will be able, on average, to reduce ten of the twelve monthly RNS peaks each year. This estimate trends conservative; Eversource expects that it may be able to exceed it.

As a general matter, monthly and summer peaks are also well correlated with circuit peaking. This means that shaving peak to obtain ISO-NE Capacity and RNS cost savings will also at the same time relieve loading on circuits providing operational and infrastructure benefits. This provides additional value for customers.

5.2.2.2 RNS

Transmission facilities in ISO-NE are funded through a pool-wide "postage stamp" rate for regional network service. Under the RNS rate, the cost of a transmission project is allocated in proportion to each ISO-NE Transmission Provider's peak electricity demand (this is referred to as "network load").

To calculate RNS savings, Eversource utilized an ISO-NE forecast of RNS through 2022 (shown in Table 5-1), then assumed an increase of 4.66% year-over for the remaining years of the analysis. Eversource is also assuming it can use the storage to hit ten of the twelve annual peaks. Eversource estimates the average annual RNS charge reduction savings achievable by the Westmoreland ESS to $348k/yr.

5.2.2.3 ISO Capacity

Load serving entities (LSE) in the ISO-NE electricity market are responsible for their share of regional capacity requirements through ISO-New England's Forward Capacity market. This is a charge collected from load serving entities and paid to generators to ensure that ISO-NE has sufficient generating capacity and that new resources are sited in the optimal location. Each individual LSE's capacity charge is determined by their yearly capacity supply obligation, representing their pro-rata share of the New England energy market load at the yearly hourly peak for New England.

Eversource's FCM forecast includes Forward Capacity Auction (FCA) prices ranging from $100/kW-yr on the high end to $57.6/kW-yr on the low end, with year-over-year changes that vary. With respect to historical auction prices, the most recent auction, FCA 13, cleared at $45.6/kW-Yr, while previous auctions have been above $100/kW-Yr, with volatility from one auction to the next. The average of the last five auctions has been approximately $79.5/kW-Yr. Eversource's analysis uses the FCA 11 clearing price of $63.6/kW-yr and grows it at inflation (2%) as to represent a reasonable price given historical volatility. Eversource assumes it would successfully use the storage assets to hit the yearly ISO-NE peak (which has historically been in the summer). Eversource estimates the average annual ISO-NE Capacity savings achievable by the Westmoreland ESS to be $120k/yr.

5.2.2.4 LNS

Eversource LNS cost reduction analysis assumes an LNS rate starting at $10/kW-Yr and growing at inflation (2%). This is consistent with Eversource's review of internal historical data. While there is inherent uncertainty around LNS rates on a year-over basis, this analysis assumes a lesser rate as a conservative assumption. Eversource estimates the average LNS charge reduction achievable by the Westmoreland ESS to be $19k/yr.

5.3 Primary frequency response

There are multiple technical mechanisms to maintain system frequency at 60Hz. One is the frequency regulation market which acts to adjust the generation of participating assets on a 4s cycle. At faster timescales, there are additional mechanisms to stabilize the system after a contingency event that causes a deviation of system frequency away from 60Hz. There are requirements and mandates from FERC, and balancing authorities can choose how to supply the resource of responsive assets to meet their portion of the obligation. ISO-NE has obligations that flow down to requirements to member utilities. In February 2018, FERC issued Order 842 mandating that all new interconnecting synchronous and non-synchronous generation facilities demonstrate the capability to provide primary frequency response services.

For frequency deviations that are less severe, the requirement is as defined in NERC Standard BAL-003-1 Frequency Response and Frequency Bias Setting.[3] Traditionally the obligation has been met by thermal generators that have governors or the modern digital equivalent, which monitor frequency locally and moderate output according to a droop curve, which defines a ΔMW/Δf response, a modulation of power output for an observed frequency deviation. This regime applies to frequency deviations in the range of Δf<0.5Hz. Events of this magnitude occur regularly.

For more extreme frequency deviations, compensatory load shedding is required to balance DERs that are required to trip offline above the threshold illustrated by the black curve shown in Figure 5-4 as per PRC-006-NPCC-1. The way that Eversource implements this requirement is that 7% of load will be shed after frequency deviations <59.5Hz that are sustained for longer than 0.3s, an additional 7% at 59.3Hz, and an additional 7% at 59.1Hz. This regime of frequency deviation is reached only very rarely. In the Eastern Interconnect, which is a very large and stiff synchronous system, frequency deviations of this magnitude occur only when a portion of the system has separated in some fashion from the bulk system. For example, the two times that it occurred in Eversource territory in the past ten years involved loss of transmission line and an isolated, local pocket of the grid remaining energized briefly by local generation before experiencing an outage. In that circumstance, an energy storage system that attempted to stabilize frequency could cause safety concerns and it is not recommended that energy storage assets attempt to take any action to support system frequency. Anti-islanding protection would preclude participation.

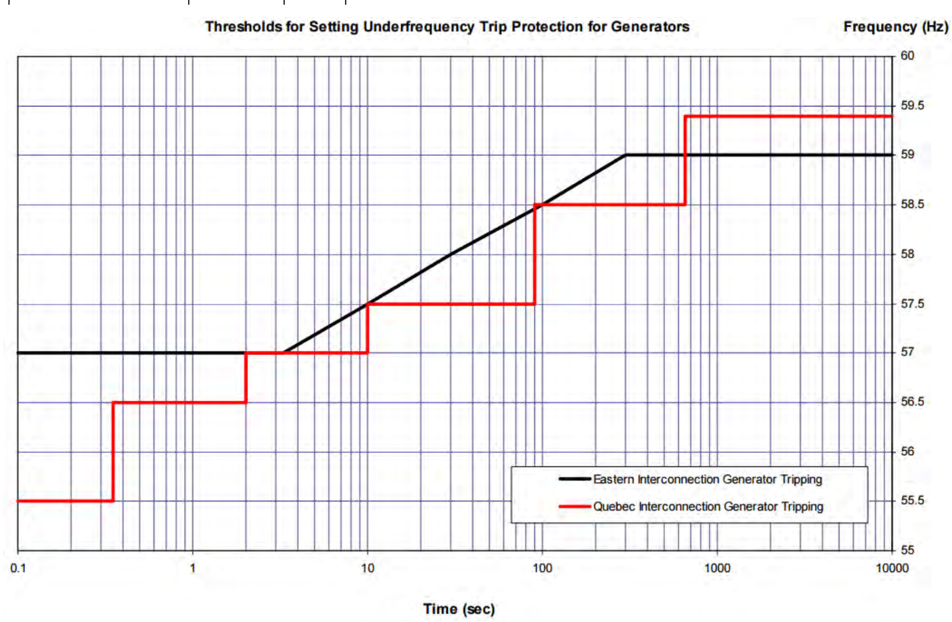

Figure 5-4 – Under frequency trip protection for generators from PRC-006-NPCC-1.

At present, there is not a shortage of governor-equipped power plants than can provide the necessary resource to respond to less severe frequency deviations, but it is anticipated that in a future energy system with very high

[3] http://www.nerc.com/pa/Stand/Project%20200712%20Frequency%20Response%20DL/BAL-003-1_clean_031213.pdf

levels of distributed and inverter-based generation, there will not be adequate supply of traditional responsive resources. FERC Order 842, issued in February 2018 in response to this expected shortage, requires energy storage assets to include primary frequency response capability. Energy storage is technically capable of providing this resource, but performance in operational conditions has not been well studied. It is recommended that the Westmoreland ESS demonstrate the application of primary frequency response using a droop-curve-like control. Demonstration of this application would establish performance expectations for inverter-based assets and provide an opportunity to develop best practices around the implementation of the control. It would allow for exploration of concerns about impact to local power quality when a frequency deviation event occurs and ESS output ramps quickly in response, and development of mitigation measures.

5.4 Sizing, costs, and benefits summary

The ESS applications discussed in Section 5 create multiple technical and economic benefits. The potential benefit must be weighed against cost and practical considerations such as risk, operational complexity, administrative overhead, and commercial availability to determine the optimal power and energy rating for the Westmoreland ESS. The valuation of each application discussed in this section is listed in Table 5-2. The primary considerations are as follows:

1. A 1.7MW / 7.1MWh ESS is recommended to operate the section of circuit 3139X downstream from the Spofford step tansformers as an electrical island during loss of service in the upstream distribution system. 1.7MW covers projected peak load on this circuit section through 2028 and, assuming the projected 2028 load profile, 7.1 MWh is a sufficient energy capacity to ride through any 4-hour outage.
2. The 1.7MW / 7.1MWh ESS that enables the above use cases is capable of achieving approximately $485k in average annual cost savings through peak shaving to reduce ISO-NE RNS, LNS and capacity charges.

For these reasons, a power and energy capacity of 1.7MW / 7.1MWh is recommended. The cost of the recommended system is discussed in further detail in Section 7.1.

Table 5-2: Benefit summary

One-time Benefits	Value ($000)
Deferred Distribution Upgrades	$ 6,000
Annual Benefits	**Average Annual Value ($000/yr)**
RNS Charge Reduction	$ 348
ISO-NE Forward Capacity	$ 120
LNS Charge Reduction	$ 19

In addition to benefits easily expressed as a dollar value, there are multiple technical benefits that have been discussed throughout this section. These include

- Gain experience designing, procuring, operating ESS
- Increase DER hosting capacity
- Develop peak shaving best practices
- Increased system reconfiguration flexibility

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- Demonstrate primary frequency response
- Improve power quality
- Enhance coordination across utility functional groups

Section 6 Conceptual Design

6.1 Battery chemistry

Based on the use-cases and reliability objectives for the Eversource Westmoreland ESS project, Lithium ion was determined to be the most suitable energy storage technology for this project.

Table 6-1 shows a comprehensive comparison of considered technologies. Out of the mature and demonstrated technologies, Lithium ion is shown to be the most cost-effective and high-performing technology given the expected use-cases and duty cycles. Sodium-Sulphur (NAS) batteries perform at the low end of their efficiency scale in the long periods without charging and discharging as specified in expected use patterns due to heating requirements to maintain operating temperature. Additionally, NAS batteries are produced at scale by a single vendor, eliminating the benefits of cost competition between large vendors seen in the Li-ion market. Lead-acid batteries are suitable for many of the same use-cases as Lithium ion but have much lower energy density. They have not seen the same decrease in price over the last decade and don't offer a significantly lower cost to justify their lower performance in this application.

Commercially unproven technologies at the multimegawatt scale such as Zinc-hybrid cathode and flow batteries were determined to be unfit for this application due to factors that would increase risks to project completion and reliability. Flow batteries are not recommended at their current technology readiness level; there has not been a large-scale demonstrated high-reliability flow battery installation. Zinc hybrid cathode batteries are both commercially unproven and are produced by limited vendors with uncertain futures. Vendor quality uncertainty, bankruptcy or acquisition could cause delays, technological problems or project unfeasibility during any stage in the design or implementation process.

Lithium ion has rapidly become the chemistry of choice for megawatt-scale utility ESS's. With over 500 MW of installed Lithium ion projects in the U.S. to date,[4] Lithium ion batteries in stationary electric grid applications is well established. It has an extremely favorable cost-curve trajectory and, due to continuing manufacturing-scale additions, the cost is expected to continue its decline. Lithium ion technology continues to dominate the energy storage market and captured over 97% of market share in 2018, both driving and being driven by declines in prices.

Lithium ion also has the highest flexibility of all battery choices considered, making it an excellent choice to demonstrate a wide range of use cases. Lithium ion batteries typically achieve > 90% round-trip efficiency, making them well suited for energy applications, and they can support the ramping requirements (power/time) of all use-cases identified for this ESS. Like most electrochemical battery chemistries, Lithium ion batteries do suffer lifecycle degradation, but the degradation expected from a Lithium ion battery is no more significant than other battery chemistries offering the same degree of flexibility; and the modular nature of Lithium ion batteries

[4] Bloomberg New Energy Finance

makes it possible to maintain capacities over the lifetime of the ESS by replacing batteries as needed or augmenting energy capacity.

Table 6-1: Comparison of battery chemistry options

Technology	Example Vendors	Technological Maturity	Size	Round-trip efficiency	Advantages	Disadvantages
Li-ion	Samsung, LG Chem, Panasonic, BYD, CATL	Mature	5 kW – 100+ MW	80-92%	Relatively mature technology, high efficiency, fit for many use cases	High capital costs accelerated degradation with high cycling frequency
Flow Batteries	Sumitomo, UET, Primus Power	Limited commercial deployment	25 kW – 100+ MW	70-77%	Power and energy independently scalable, no degradation of capacity over thousands of cycles, no fire risk	Relatively high balance of system costs, reduced efficiency during rapid charge/discharge use cases (high auxiliary power load)
NAS	NGK (sole vendor)	Mature	1 MW – 100+ MW	75-90%	Relatively mature technology, high energy capacity and long duration	Maintaining high operating temperature leads to high auxiliary power costs in infrequent use cases, flammability issues
Zinc	Eos, Fluidic Energy	Unproven	5 kW – 100+ MW	75%	Projected low cost	Unproven cost from limited vendors, lower efficiency, unproven commercially
Lead Acid	GS Yuasa, Enersys, East Penn Mfg.	Mature	5 kW – 2 MW	63-90%	Established recycling infrastructure, low cost relative to li-ion	Poor depth of discharge, short lifespan, poor ability to operate at partial SOC

6.2 Major system components

The System design details that follow give a top-level overview of the components and design considerations for an ESS project at the Westmoreland site. The descriptions and diagrams presented are representative of typical systems and, once the component vendors have been selected and detailed designs have been established, may vary from what is eventually deployed.

The ESS is comprised of the following major components: Battery System; Power Conversion System (PCS); Control Cabinet; Step-Up Transformer; and other BOS components. Figure 6-1 shows the basic layout of a generic ESS with the major components identified. ESS design specific to the Westmoreland project is provided in the following sections.

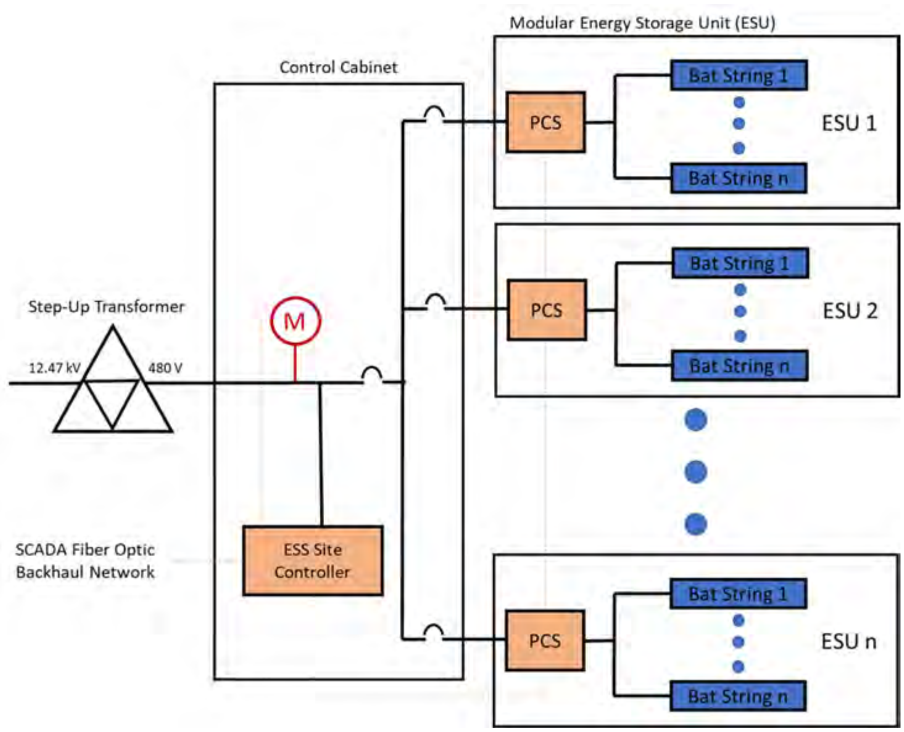

Figure 6-1 – ESS block diagram

The blue boxes (B1, B2, B3) in Figure 6-1 represent the battery racks in each Energy Storage Unit (ESU). The actual number of battery racks will vary depending on the vendor and system configuration.

6.2.1 Battery System

The battery system includes racks of battery modules, a Battery Management System (BMS) for monitoring and control, DC connections, and switchgear to connect each rack to the common DC bus. The battery container includes heat, ventilation, and air-conditioning (HVAC) systems that keep the batteries within their rated temperature range. The battery container will also be equipped with sensors, fire alarms, and fire-suppression equipment. Fire suppression systems for lithium ion batteries are triggered by a combination of heat and smoke detection. Alarms will alert any on-site personnel and operators in the control room. Fire suppression can be accomplished by a non-damaging clean agent type system, in which a fire suppressant gas is released to fill the container volume and suppress a fire so that it does not propagate from a faulty cell to adjacent battery cells. Alternatively, or additionally, a water-based fire suppression system may be used, which is non-toxic but has the disadvantage of destroying all equipment within a container.

Battery form factor can be in a modular format (e.g. Tesla layout) or in a containerized format (e.g. LG Chem, Samsung). Batteries should be enclosed in a NEMA 3R[4] container. Lithium ion battery modules are fully sealed and do not release any emissions under normal operation.

6.2.2 Power Conversion Systems (PCS)

The Power Conversion System (PCS) stands between the ESS and the grid, converting the ~1000VDC of the battery system to the 480VAC, 60 Hz of the electric grid, and vice versa. It also provides critical system protection and operating functionality, such as anti-islanding protection (to prevent unintentional islanding) and power conditioning. The PCS connects to the battery container using a DC connection at a voltage that varies according to battery SOC. The utility side of the PCS has a 480VAC, 3-phase AC output that connects to the ESS connection transformer.

Figure 6-2 – Typical 1.25MVA containerized PCS from S&C electric company

Inverter power quality should conform to UL-1741-SA requirements and standard utility requirements. Total Harmonic Distortion (THD) and Total Demand Distortion (TDD) are less than 5%. Inverters should be equipped with AC and DC disconnect switches as well as a DC contactor.

6.2.3 Control System Software and the MESA Standard

Eversource will operate the ESS as an integrated system with Control System Software that provides monitoring and alarm capabilities. The Modular Energy Storage Architecture (MESA) provides a standards-based communications network that enables Eversource to interact with this and any future ESS using a similar DNP3 communications profile, significantly reducing engineering costs. The MESA protocol also employs multiple advanced ESS control algorithms that dispatch the ESS to achieve the desired use cases on the grid.

[4] For NEMA 3R Definition: http://www.nema.org/Products/Documents/nema-enclosure-types.pdf

Information on the MESA standard can be found at www.mesastandards.org. By standardizing the communications interface between multiple components within the ESS, and between the ESS and Eversource's SCADA platform, the MESA Standard enables Eversource to control the ESS and subsequent ESSs that may be installed in a consistent manner. The MESA Standard also drives out non-recurring engineering costs as additional ESSs are deployed by standardizing system design.

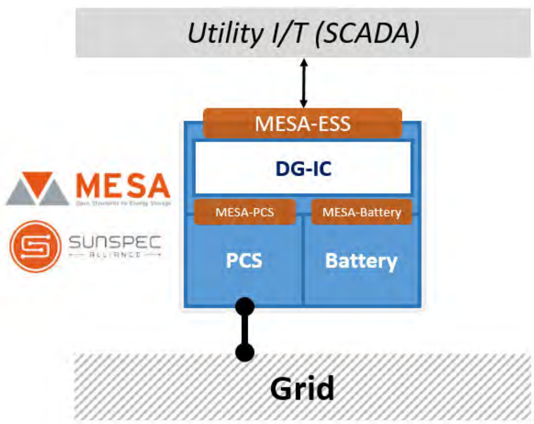

Figure 6-3 – MESA Standard block diagram between ESS components and utility

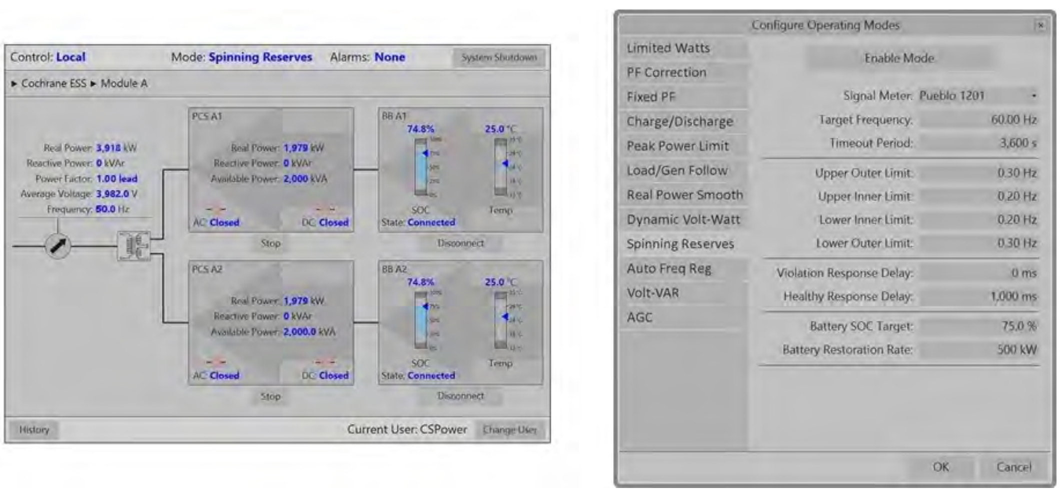

Figure 6-4 – Doosan GridTech Intelligent Controller (DG-IC) example control screens.

6.2.4 ESS Disconnect Switch Cabinet

To comply with Eversource safe work practices, a visible and lockable means of disconnecting the ESS from all components on the utility side of the point of common coupling (defined as the 480V terminals of the utility transformer) will be provided. The ESS Disconnect Switch will electrically isolate the ESS connection transformer. An ESS output meter and automatic tripping coordinated via installed relays may be installed if required. Exact specifications will be determined during the detailed design phase of the project.

The switch enclosure will be appropriately grounded to the ground grid and will be equipped with ground fault detection if required.

6.2.5 Control Cabinet

Utility personnel will locally control ESS operations via a Control Cabinet that houses the ESS networking and control hardware. The Control Cabinet will include the controller platform (typically an Advantech UNO 4600 series computer), the system display and control interface (typically a 19" touchscreen), and all equipment necessary to communicate with the PCS, batteries, and internal system meters, as well as external points, like solar output meter telemetry.

The Control Cabinet is typically an outdoor rated, pad-mounted cabinet. 120V AC auxiliary power is typical. The Control Cabinet will also include an uninterruptable power supply (UPS) to power critical control and monitoring components in the event of a grid outage. The UPS will be sized during the detailed design phase to achieve a minimum of 1 hour for a safe and controlled shutdown of ESS components during an outage. Longer back-up times are possible by adding additional UPS units. DC auxiliary power options are available and may be advantageous to include in addition to AC. Such a design may offer resiliency to lengthier loss of AC power, up to 8 hours, and would be consistent with substation designs that Eversource staff are accustomed to.

Figure 6-5 – Typical control cabinet

6.2.6 Step-up Transformer

The step-up transformer converts between the distribution voltage (12.47 kV nominal) to ESS inverter output voltage (480V). Typical ESS components are compatible with both WYE-WYE and DELTA-WYE transformers. Alternative transformer configurations are also possible, including Grd-Y/Grd-Y, and depending on Eversource's preference for distributed generation, may be evaluated and selected during the detailed design phase.

The detailed design phase will also consider the appropriate transformer K-factor, exact windings ratio, and tap position to ensure safety and reduced wear and tear on the transformer. Typically, the step-up transformer will include a no-load tap changer that can be adjusted +/-5% if required by change in substation design or load reconfiguration. ESS connection transformers are commonly over-sized due to the potential operation of the ESS across a wide range of its four-quadrant response capabilities. Lessons learned from early deployments of ESSs of this scale suggest that a larger transformer rating is advisable.

6.2.7 Site Enclosure and Access

The entirety of the ESS will be enclosed by a fence no shorter than 8 feet. The access should allow for service vehicles, e.g., a vehicle to add or remove battery modules, to access the ESS. All ESS components should have pad-lockable doors to prevent unauthorized access.

6.2.8 Metering

Metering is required within the ESS and the surrounding grid infrastructure to:

- Provide an input signal to the site controller of local grid conditions to dispatch various Modes of Operation;
- Provide indication of ESS system output (active and reactive power) to ensure system operation is as expected;
- Enable measurement of key performance parameters for ESS evaluation, and;
- Track usage of auxiliary power to factor in to ESS efficiency.

Table 6-2: Metering requirements

Meter	Purpose	Meter type
ESS output	Provides kW, kVAR, pf, voltage, and frequency at the ESS output. Used for multiple modes to control ESS performance.	3Φ Bi-directional or equivalent (ION 8650 or equivalent)
ESS auxiliary power	Records the auxiliary power used for internal ESS loads (such as HVAC). TBD depending upon the technology selected.	Revenue meter with modbus communications capability (ION-6200 or equivalent)
ISO-NE revenue meter	TBD, dependent on ISO-NE market requirements and Eversource market strategy.	TBD

6.2.9 Auxiliary Power

Auxiliary power for most battery and PCS components is powered from the 480V AC bus at the PCS output and therefore does not require a separate 480VAC service from Eversource. The 480V auxiliary power bus normally requires a 1:1 isolation transformer between the PCS output and the ESS components. Components in the control cabinet require a 120V 1Φ supply of auxiliary power that is typically sourced from the battery container. The control cabinet components will include an embedded UPS to provide short-term power if the normal source of auxiliary power is lost.

6.2.10 Grounding Protection

The ESS will connect to an underground grounding grid that will be connected to a newly constructed ground grid for the ESS. Additional grounding conductors, to be specified during the detailed design phase, will be installed within the ESS site. A detailed ground report will be provided during the detailed design phase, including grounding impedance requirements.

The chassis/enclosures of all ESS components will be connected to the grounding grid to reduce touch potential hazards. The PCS's and 480V disconnect enclosure will have neutral points connected to the ground grid. The battery modules will be chassis grounded, though batteries often operate with a floating DC system that is not grounded.

6.3 Interconnection and Protection

Based on a preliminary review of the existing 3139X infrastructure, and a consideration of intended use cases, the recommended interconnection approach is shown in Figure 6-6. A 480V / 12.47kV step-up transformer is used to transform the PCS output to 12.47kV. A three-phase recloser will be installed that can electrically isolate the ESS from the distribution line. The energy storage system will have a robust set of protective equipment that will protect the device from grid conditions such as overcurrent, under and overvoltage, for example.

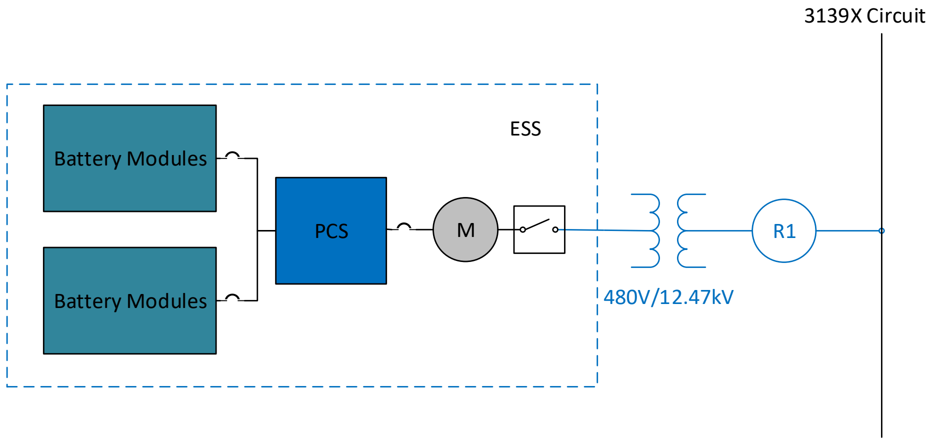

Figure 6-6 – Interconnection diagram

Standard protection used by Eversource allows reverse power flow under current settings. It is not anticipated that any existing protection equipment will have to be replaced or reconfigured to permit reverse power flow.

An interconnection and system protection study should be completed during the detailed design stage to verify configuration.

The system protection study during the detailed design phase should pay special attention to the protection scheme during islanding. The inverters spec'd in the conceptual design and project budget have a 200% short-term overload capacity (consistent with inverters Eversource is currently deploying for islanding-capable projects in the field). This can help with low fault current concerns, but a detailed study to identify necessary protection scheme changes should be performed.

6.4 Site and physical layout

6.4.1 Site characteristics

A strong candidate site for the Westmoreland ESS has been identified northwest of the Westmoreland town center near the Connecticut River. Figure 6-7 shows the identified parcel of land. This location is preferred due to its proximity to critical loads and expected ease of land acquisition. This plot is located adjacent to the Cheshire County nursing home critical load and is one mile from the concentrated critical loads in the Westmoreland town center. Indications from preliminary contact with the current owner are that the property is available.

Figure 6-7: ESS candidate location

The area to the northeast of the access road was identified as a floodplain, but the land marked in Figure 6-7 is viable for ESS construction.

The following image shows the candidate site in relation to the town center that includes the elementary school (that serves as the town emergency shelter), the town fire station, Town Hall, the post office, a general store, and a Consolidated Communications building.

Figure 6-8: Proposed site relation to critical loads

6.4.2 ESS physical layout

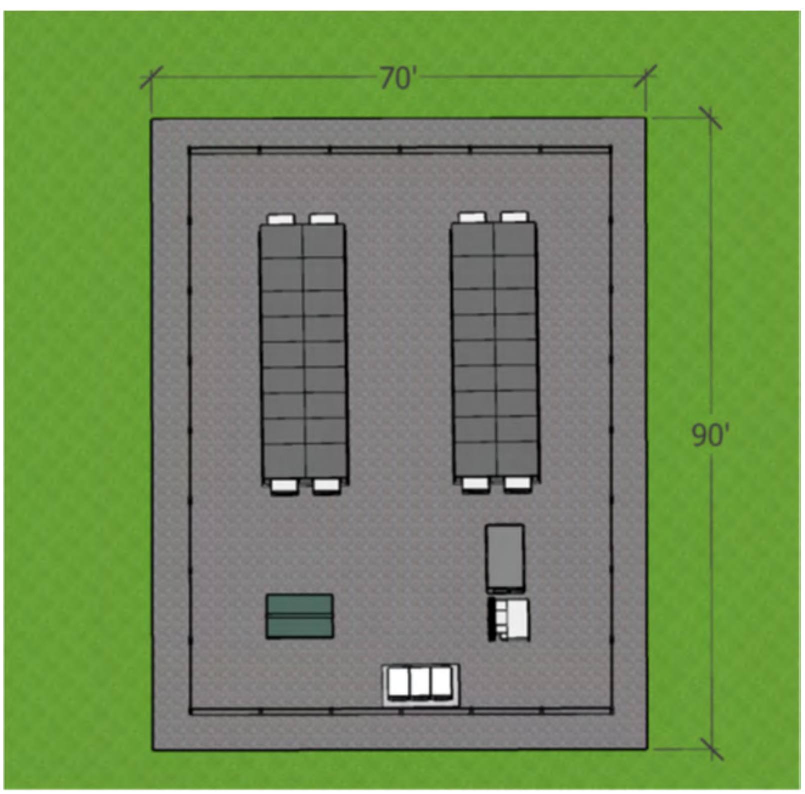

Figure 6-9: Westmoreland ESS physical layout and footprint dimensions

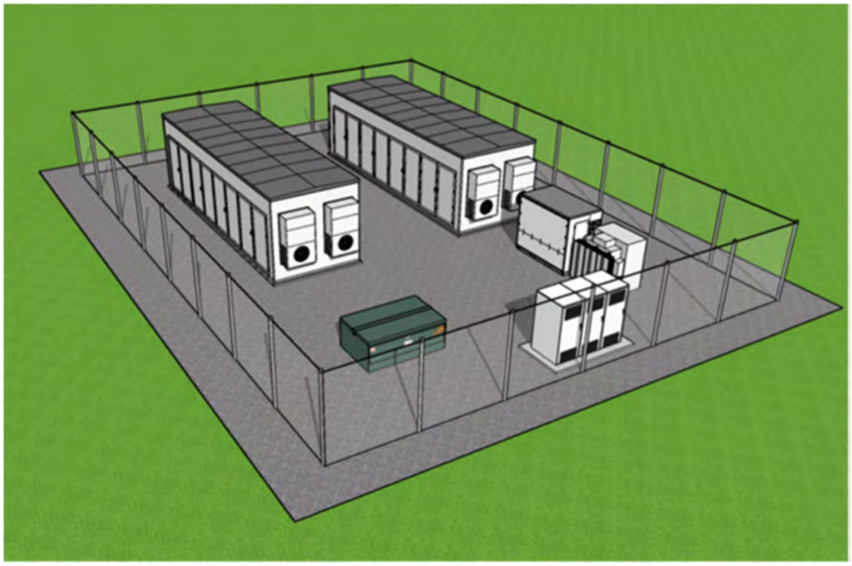

Figure 6-10: Angle view of ESS equipment layout

6.5 Communication

There is no existing communications infrastructure at the preferred Westmoreland site, so new communications equipment must be installed to implement the use cases of the demonstration ESS. Eversource uses a DSCADA system to remotely monitor and control equipment in other parts of the system; so, the Westmoreland ESS will be integrated into the existing system. A Remote Terminal Unit (RTU) will be installed at the site and data transmitted through wireless or radio link

The Westmoreland ESS site controller shall interface with the Eversource DSCADA system for indications, alarming, control and configuration parameters. A separate interface shall allow a remote user access for troubleshooting and monitoring. These interfaces will operate over a secure connection to Eversource's backhaul OT network.

All operational interaction with the site controller will be accomplished through an existing DSCADA platform. Interfaces between the DSCADA system and the site controller will leverage DNP3. All Eversource DNP3 interaction will be over IP connections regardless of the physical medium. The site controller implementation of the MESA-ESS DNP3 interface will be tested and certified. If Eversource chooses to pursue direct participation in ISO-NE markets in the future, these operations will be managed by a market services contractor.

Remote desktop protocol (RDP) or Internet Protocol Security (IPsec) will be available via a VPN connection to users external to Eversource's network for troubleshooting and remote monitoring. Such access may be continuous to allow for a permanent flow of data or may be limited instances (single-session) for troubleshooting or extracting log files. External remote control of the ESS will be allowed only if desired by Eversource. User accounts and permissions for the VPN tunnel will be configured and managed by Eversource.

Eversource will configure all network connectivity appliances (such as switches, routers, firewalls, etc.) as needed to establish IP connectivity to the site controller. Any network connectivity appliances supplied as part of the ESS will be subject to the approval of Eversource's Network Operations team to ensure interoperability with Eversource's existing network equipment.

The MESA-ESS interface will include the DNP3 points list that Eversource will use within the DSCADA system to monitor, dispatch and configure the ESS via the site controller. This list shall be submitted to Eversource as part of the "DNP Device Profile Document".

Operator control and decision-making between use cases needs to be determined at a later stage of detailed design.

6.6 Certification and Testing

6.6.1 Certifications

Because grid-tied energy storage systems are comprised of several different components, multiple Nationally Recognized Test Laboratory (NRTL) certifications apply to them. There are a significant number of certifications that can apply to utility-sited ESS.[5] An overview of recommended certifications and standards is included in Table 6-3.

Table 6-3: Recommended ESS standards and certifications

Number	Title	Notes	Link
IEEE 1547-2018	Standard for Interconnecting Distributed Resources with Electric Power Systems		https://standards.ieee.org/standard/1547-2018.html
IEEE 1547.1-2005	Standard for Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems		http://standards.ieee.org/findstds/standard/1547.1-2005.html
IEEE 1547.1a-2015	Amendment 1 to IEEE 1547.1-2005		https://standards.ieee.org/findstds/standard/1547.1a-2015.html
IEEE 2030.3-2016	Standard for Test Procedures for Electric Energy Storage Equipment and Systems for Electric Power Systems Applications		http://standards.ieee.org/findstds/standard/2030.3-2016.html
IEEE 2030.2-2015	Guide for the Interoperability of Energy Storage Systems Integrated with the Electric Power Infrastructure		http://standards.ieee.org/findstds/standard/2030.2-2015.html
IEEE P2030.2	Draft Guide for the Interoperability of Energy Storage Systems Integrated with the Electric Power Infrastructure	Draft	
IEEE 1679-2010	Recommended Practice for the Characterization and Evaluation of Emerging Energy Storage Technologies in Stationary Applications		https://standards.ieee.org/findstds/standard/1679-2010.html

[5] Inventory of Safety-Related Codes and Standards for Energy Storage Systems. Pacific Northwest National Laboratory (PNNL-23618), September 2014.

IEEE 519-2014	Recommended Practice and Requirements for Harmonic Control in Electrical Power Systems		https://standards.ieee.org/findstds/standard/519-2014.html
NFPA 70: NEC 2014	National Electric Code (applied to balance of system design principles, not applicable as an equipment standard)		http://catalog.nfpa.org/NFPA-70-National-Electrical-Code-NEC-Handbook-2014-Edition-P15728.aspx
IFC Section 608 2015	International Fire Code – Stationary Storage Battery Systems		http://sfmd.az.gov/documents/2016/03/2015-ifc.pdf
MESA-ESS 2016	MESA-ESS Draft Specification	Draft 1	http://mesastandards.org/mesa-ess-2016/
MESA-PCS Specification 2017	SunSpec Inverter Models 103, 113, 120, 121, 122, 123, 124, and MESA-PCS Extensions model 64800	Draft 2	http://mesastandards.org/mesa-device/
MESA-Storage 2016	SunSpec Energy Storage Models 802, 803, 804, 805	Draft 4	http://mesastandards.org/mesa-device/
MESA-Power Meter 2015	SunSpec Power Meter Models	Draft 4	http://mesastandards.org/mesa-device/
MESA-Device Model 64802	Example of a customized vendor model for a battery container	Other custom models can be created as necessary	
IEC 60086-4:2014	Primary batteries - Part 4: Safety of lithium batteries		https://webstore.iec.ch/publication/671
IEC 61000-6-3:2006	Electromagnetic compatibility (EMC) - Part 6-3: Generic standards - Emission standard for residential, commercial and light-industrial environments	Edition 2	https://webstore.iec.ch/preview/info_iec61000-6-3%7Bed2.0%7Den_d.pdf
UL 9540 2016	Standard for Energy Storage Systems and Equipment	Edition 1	https://standardscatalog.ul.com/standards/en/standard_9540
UL 1741-2010	Inverters, Converters, Controllers and interconnection System Equipment for Use with Distributed Energy Resources	Edition 2. Must comply with Supplement A (released 2017)	https://standardscatalog.ul.com/standards/en/standard_1741_2
UL 1642-2012	Standard for Lithium Batteries	Edition 5	https://standardscatalog.ul.com/standards/en/standard_1642_5
UL 1973 -2013	Standard for Batteries for Use in Light Electric Rail Applications and Stationary Applications	Edition 1	https://standardscatalog.ul.com/standards/en/standard_1973_1
UN Manual of Tests and Criteria, 6th Ed, 38.3	Recommendations on the Transport of Dangerous Goods, UN Manual of Tests and Criteria, Lithium metal and lithium ion batteries	Lithium-ion batteries classified as UN 3480 in Hazard Class 9	http://www.unece.org/trans/areas-of-work/dangerous-goods/legal-instruments-

			and-recommendations/un-manual-of-tests-and-criteria/rev6-files.html
49 CFR Subtitle B Chapter I (2017)	Code of Federal Regulations, Title 49 (Transportation), Pipeline and Hazardous Materials Safety Administration		https://www.ecfr.gov/cgi-bin/text-idx?SID=f2a9254e05937b161fab6ac647fd853c&mc=true&tpl=/ecfrbrowse/Title49/49tab_02.tpl
47 CFR, Chapter I, Part 15 (2017)	Code of Federal Regulations, Title 47 (Telecommunications), Radio Frequency Devices	Class A - Device marketed for use in business/industrial /commercial environments	https://www.ecfr.gov/cgi-bin/text-idx?SID=f2a9254e05937b161fab6ac647fd853c&mc=true&node=pt47.1.15&rgn=div5

6.6.2 Acceptance Testing Requirements

Testing of the ESS will be done in four phases between the design phase and the final turnover to Eversource, as follows:

1. Factory Integration Test. Occurs at the manufacturer's facility. The primary purpose is to witness the functionality, performance, controls, safety, and alarm communications of an Energy Storage Unit (ESU) prior to shipment. An Eversource-provided EMS/SCADA test set may be utilized for end-to-end communication checks.
2. Commissioning Testing. Designed to verify the proper installation, operation and interconnection of all components of the ESS after it is fully installed in the field. Ensure all components meet all contractual specifications and performance obligations. A third-party commissioning agent will be used.
3. Final System Acceptance. Final testing verifies proper functionality of the ESS under the full stack of controls from the utility SCADA system, through the site controller, to the individual components.
4. Field Performance Testing. Designed to evaluate the long-term performance of the ESS in various modes of operation. This may occur several weeks or months after commissioning.

Eversource and the EPC firm will jointly develop detailed plans for each stage of testing. Completion of each test, including the submission of a test report, is required prior to completing each milestone.

Test plans will, at a minimum, include the following:

1. Failure Modes and Effects Analysis
2. Non-operational Tests and Preparation
    a. Test insulation resistance.
    b. Check control power.
    c. Check protection and setpoints.
    d. Check control/communications wiring and signals.
    e. Check firmware load/software communications.
    f. Test E-stops and door interlocks.

   g. Test for loss of power.
   h. Test for restoration of power.
   i. Test subsystems (for example, the cooling system).
3. Local Operational Testing
   a. Verify operation of all protective functions specified in IEEE 1547 and UL1741-SA, including transfer trip and anti-islanding.
   b. Verify operation of all safety features and alarms (via actual or simulated trigger) that can be reasonably tested in the field.
   c. Shutdown testing: manual, emergency, site controller failure, PCS alarm, communications failure, HVAC failure.
   d. Verify operation of each PCS/battery module using local controls.
   e. Verify low power charge and discharge.
   f. Verify reactive power dispatch.
4. Site Controller Operational Test – Local System
   a. Verify that the site controller is configured and successfully communicates with the full ESS.
   b. Issue a system start and system stop command.
   c. Test charge, discharge, and reactive power dispatch, ramping from low to high power levels.
5. Performance Testing
   a. Operate the system at full charge and discharge capacities.
   b. Dispatch the system from 100% SOC to 0% SOC and the reverse.
   c. Operate the system at half power charge and discharge states, and document energy transferred.
   d. Evaluate round trip efficiency.
6. Eversource-site controller Operational Test – Full System
   a. Verify that the Eversource-site controller communications link is configured and successfully transmits commands and all SCADA points.
   b. Issue a system start and system stop command.
   c. Test/Demonstrate all operational modes of system by remote control via SCADA.

Eversource will be responsible for the following regarding Final System Acceptance testing of the ESS:

- Inspection and approval of final installation before initial energization
- Initial energization
- Measurement of equipment and site noise emissions

Section 7 Conceptual Project Plan

Eversource typically chooses to engage an Engineering, Procurement, and Construction (EPC) firm for new infrastructure such as transmission lines, solar PV farms, and, in future, energy storage systems. The conceptual project budget and project schedule discussed in this section have been developed with the assumption of an EPC procurement model. EPC firms take full responsibility for design and engineering (with input and review by Eversource in-house engineers), procurement of all hardware, management of all subcontractors, and oversee the construction process. The EPC procurement model provides the lowest risk and complexity for Eversource.

7.1 Project budget

The following budget is indicative of the budget that would be required to implement the recommended Westmoreland ESS using the preferred procurement and project execution structure. This section discusses 25-year lifetime expenditures in three categories: EPC capital budget in Section 7.1.1, Eversource direct capital expenditures in Section 7.1.2, and operating and maintenance budget in Section 7.1.3. Eversource typical overhead, and loaders were applied, with a contingency of 20%, and the total, loaded budget requirement is summarized in Table 7-1. The total beginning of life (BOL) capital budget is $7.0M, and the O&M budget is $140k/year. A $1.2M module replacement capital expenditure is expected after 12 years, though this number may change significantly due to market changes and evolving technical needs.

Table 7-1: Project Budget Summary in $000

<table>
<tr><th colspan="2">Budget Elements</th><th>2020</th></tr>
<tr><td colspan="2">Total EPC capital budget, fully loaded</td><td>$4,328</td></tr>
<tr><td rowspan="6">Eversource Direct Capital Expenditures (line items fully loaded)</td><td>Eversource staff labor including EE, PM, legal</td><td>$1,491</td></tr>
<tr><td>Permitting</td><td>$176</td></tr>
<tr><td>Systems Integration</td><td>$171</td></tr>
<tr><td>Site Development and Building</td><td>$562</td></tr>
<tr><td>Interconnection Switchgear, Aux Power Equipment, and Communication</td><td>$273</td></tr>
<tr><td>Total Eversource direct spend, fully loaded</td><td>$2,674</td></tr>
<tr><td colspan="2">Project Capital budget total, fully loaded</td><td>$7,002</td></tr>
</table>

7.1.1 EPC capital budget

The budget presented here provides externally sourced services and materials that fall under the EPC firm's responsibility. Estimates are based on recent market activities and assume a 1.7MW / 7.1MWh ESS is procured, installed, and implemented as per the recommendations in this report. Cost estimates are representative of multiple suppliers who meet recommended requirements.

Doosan recommends securing an unloaded BOL EPC project budget of $3.5M. Table 7-2 breaks down the EPC budget into major categories, and Figure 7-1 charts the allocation of the total budget among major categories. EPC project management, commissioning, and labor is spread evenly among the equipment categories.

Public Service Company of New Hampshire
d/b/a Eversource Energy
Docket No. DE 19-057

Table 7-2: EPC budget (unloaded)

Description	Total Cost
Enclosure(s) including climate control equipment and fire suppression systems	$212
Battery Systems and Battery Management System	$2,088
Power Conversion Systems and Transformers	$354
Balance of System	$319
Contract Labor and PM	$566
Total ESS Budget (unloaded)	$3,539

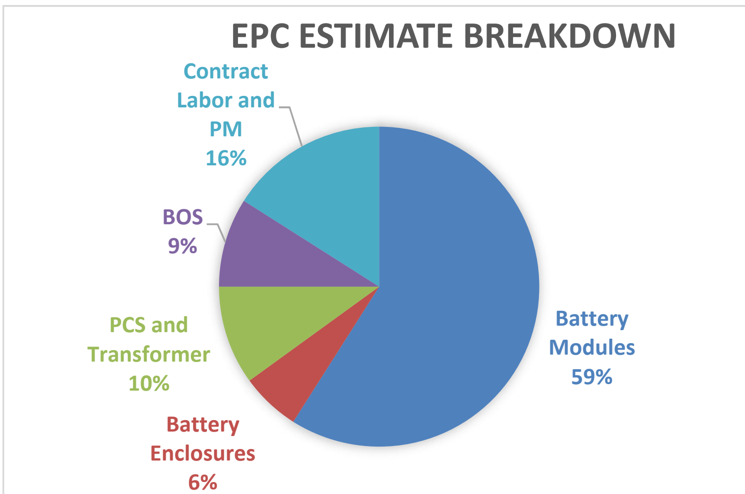

Figure 7-1 –EPC budget allocation among major project elements.

The EPC budget was developed with the design parameters and assumptions detailed in Table 7-3. The nameplate power and energy capacity drive the budget. The energy capacity of Lithium ion batteries degrades over the asset lifetime, due to a combination of factors including calendar life aging, the effect of cycling, and exposure to stressors such as high or low temperatures.

This estimate assumes the BOL system will be oversized to maintain a 7.1MWh AC energy capacity at the POI for 12 years. Battery module replacement at after 12 years will be required to maintain this 7.1MWh energy capacity for the 25-year project lifetime. Doosan currently projects this replacement to cost $1.2M, but this estimate is highly uncertain at this time. Eversource's ESS objectives and technical requirements may also evolve before within the first 12 years, and a different energy capacity or ESS technology may be implemented.

The training that is included in this budget estimate is substantial, since this this would be one of the first assets of this type in the Eversource NH service territory. It would include in-class, on-site, and interactive video training over six modules for operators, maintenance staff, engineering staff, utility first responders, and community first responders. The modules would cover an overview of the system, design and commissioning, operations, on-site safety and maintenance, on-site safety and emergency response, and technical library. Curriculum and interactive modules would be an enduring resource for Eversource for new staff.

Table 7-3: Design parameters used to create EPC budget

Parameter	Value
Electrical	
MW	1.7MW
MWh (AC) at interconnection at end of life	7.1MWh
Interconnection voltage (kV)	12.47kV
Interconnection switchgear	in Eversource scope
Aux power equipment	in Eversource scope
Performance	
DC efficiency (%)	90%
AC efficiency (%)	96%
Project life	25 years (module replacement after 12 years)
Cycle/day	Zero-one at 100% depth of discharge
Retention factor (%)	78%
Annual availability	97%
Augmentation	not in budget provided, possible if desired
O&M, Warranty	
Standard warranty	2 years
Maintenance	Included in O+M estimate
Extended warranty	annual over project lifetime after year 2
Other	
Training	in EPC scope
Site preparation	in Eversource scope
Permits	in Eversource scope
Civil Construction	in EPC scope
Electrical Construction	in EPC scope
Project start date (Award)	Jan-20
Project end date (COD)	Sep-21
Tax	not in budget
Shipping	included in budget
Performance bond	not in budget

7.1.2 Eversource direct capital spending

There are elements of an ESS that would not fall under the responsibility of the EPC firm, but rather require direct expenditure by Eversource in the form of labor and/or materials. Some of those items are indicated by blue background in Table 7-3. They are discussed in this section. The costs given in this section are unloaded budget estimates, and the fully loaded estimates are summarized in Table 7-1.

- Interconnection switchgear: $125k installed cost: Eversource purchases this equipment in volume and must interconnect DERs according to internal standards and guidelines, which require a three-phase recloser. This work falls under the purview of Eversource staff. The boundary line between the EPC firm's scope and Eversource scope is the high side of the step-up transformer.

- Auxiliary power equipment: $10k installed cost. Equipment required to power auxiliary loads such as the climate control system of the battery enclosures, auxiliary loads of the battery and PCS, and the control cabinet and site loads is most efficiently purchased and installed by Eversource. For a system of this size, the equipment would typically include a transformer rated at 100kVA, a revenue meter, and a panel with breakers at 480V and 120V.
- Radio equipment: $40k. Radio equipment required for secure communications between Eversource control center and ESS site.
- Site development: $460k. Work in this scope will consist of preparing the Westmoreland property, requiring some grading and retaining walls to provide a level yard. It will include tree clearing as necessary, trap rock, ground grid, and enclosure with substation fencing.
- Permitting and evaluation: $100k. Necessary permits include the Eversource interconnection study, wetlands delineation, endangered species review, archeological survey, civil site plan design, Federal, State and local permitting and environmental monitoring during construction. The assembly of materials for each application and submission will be managed by Eversource staff. Some design documents required for permit application packages will be produced by the EPC during detailed design phase 1.
- Systems integration: $100k. Includes work by Eversource IT staff to integrate control of ESS into the SCADA and operations systems. Because it is likely that polling will be required, a system with more bandwidth will be required, so a conservative estimate of $100k was used in the total budget.
- Eversource EE labor: $90k. Eversource engineering staff time will be required to carry out work within Eversource's scope, and to provide required system information to the EPC firm, review and approve design documents, and support testing and commissioning work. This effort is estimated as 9 months of full-time equivalent labor over the lifetime of the project.
- Eversource project development, project management, and program management: $675k. Eversource staffing to manage ESS program and individual projects from the development stage through commissioning. This estimate assumes that some of these costs will be split among multiple ESS projects
- Eversource legal: $94k. Eversource legal staff will assist in several stages of project development. These estimates all assume that this effort will be repeated across multiple ESS projects and common templates used where possible.
    - RFP development: $7.5k. Eversource legal staff will assist in developing a Request for Proposal for the EPC scope.
    - Contract template development: $7.5k. Eversource legal staff will assist in developing a template for the EPC contract.
    - Vendor negotiation: $19k. Eversource legal staff will negotiate contracts with vendors including the EPC firm.
    - Real estate transactions: $60k. Eversource legal staff will review and assist in completing the required real estate transaction.
-

7.1.3 Operating and maintenance

A total operating and maintenance (O&M) budget of $140k/year includes O&M for all components, software and troubleshooting services, plus an extended warranty on all system components in the EPC scope. It includes planned preventative maintenance for major system components: battery, PCS, containerization (HVAC, fire suppression), switchgear, and transformer. It would also include software updates, such as security patches and operating system updates. Finally, it would include troubleshooting services, so that if something goes wrong, assistance would be provided to ESS staff in interpreting alarms and identifying components in need or service or replacement.

This estimate is based on multiple recent quotes and is indicative of average costs in the industry. Because energy storage is a relatively nascent field, there is larger uncertainty in costs that will be incurred later in life than there is in upfront capital costs. Different vendors may quote O&M services with as much as 50% variance in cost for the same package of services. The O&M budget of $140k/year should be considered to have +/-50% uncertainty.

7.2 Project schedule

The project schedule described herein includes anticipated activities from the project start to the operation of the Westmoreland ESS.

Eversource plans to file the proposed demonstration project plan with NHPUC in 2019. NHPUC is expected to issue a ruling in early-mid 2020, and the project schedule shown in Figure 7-2 begins in May 2020. The major steps include the project initialization process, regulatory and permitting engagements, detailed design, procurement of ESS components, site preparation, ESS installation, ESS commissioning and acceptance testing, and final transition of the ESS to Eversource. The project schedule spans 18 months, with final acceptance and project closeout concluding in late 2021.

A summary of major project activities and dates is included in Figure 7-2 and in Table 7-4. This typical schedule is based on past project experiences and serves as an estimate and starting point for the Westmoreland ESS schedule. This schedule assumes a 1-month EPC contracting period. Doosan has experienced a wide range of contracting period durations with utilities (from well under a month to several months) and the final turnover to utility control could extend beyond 18 months from project initialization if the contracting period for this project is at the higher end of this range.

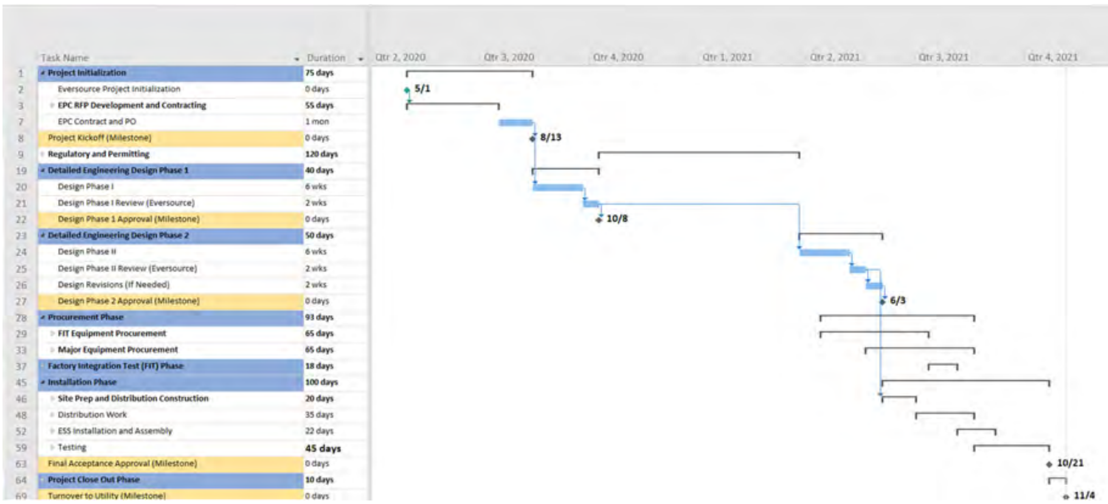

Figure 7-2 – Conceptual ESS project schedule.

Table 7-4: Major components of project schedule

Element	Average Duration	Description
Eversource project initialization: issue RFP		Send Request for Proposal (RFP) to EPC firms
EPC RFP submittals and Eversource review and selection	8 weeks	Collect RFP submissions from EPC firms, evaluate submissions according to criteria, and select preferred vendor and backup
EPC contract and PO	4 weeks	Finalize contract with EPC, issue PO and kick off project
Detailed Engineering Design Phase 1	8 weeks	Detailed engineering design resulting in design documents required for regulatory and permitting packages
Regulatory and permitting	17 weeks	Prepare, file, and receive approval on regulatory and permitting steps
Detailed Engineering Design Phase 2	10 weeks	Detailed engineering resulting in approved "For Construction" drawings from EPC to Eversource.
Procurement Phase	13 weeks	Issue PO's for equipment to begin lead times from suppliers.
Factory Integration Test	18 days (2-day Eversource visit to factory)	Test integrated components at supplier factory per FIT plan. Eversource witnesses testing for 2 days.
Site Preparation and Distribution Construction	3 weeks	Preparation of site by civil contractor and BOS electrical contractor. Construction of necessary distribution system additions/upgrades. All using "For Construction" drawings.
Distribution Work	5 weeks	Install transformers, install and connect medium voltage equipment, and interconnection process.
ESS Installation and Assembly	3 weeks	ESS equipment arrives on-site. Equipment is installed and electrically connected.

Communications integration, commissioning, and final acceptance testing	7 weeks	Connect ESS to utility network. Verify SCADA connection and points check. Progressively energize and test ESS components. Conduct first charge and discharge. Test all ESS functions. Document performance characteristics in Final Acceptance Report.
Project closeout and turnover to Eversource operations	2 weeks	Create as-built drawings, warranty documentation, punch list closeout, and personnel training. Place ESS in service. Provide all documentation to Eversource. Turn over to utility.

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[1]	Year Counter	**Inv Year 1**	**Inv Year 2**	**Inv Year 3**	**Inv Year 4**	**Inv Year 5**	**Inv Year 6**	**Inv Year 7**	**Inv Year 8**	**Inv Year 9**	**Inv Year 10**	**Inv Year 11**
[2]	Year Counter	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
[3]	Battery kW		1700									
	Benefits											
[4]	RNS Rate	$123.00	$129.00	$135.00	$141.29	$147.88	$154.77	$161.98	$169.53	$177.43	$185.69	$194.35
[5]	LNS Rate	$10.00	$10.20	$10.40	$10.61	$10.82	$11.04	$11.26	$11.49	$11.72	$11.95	$12.19
[6]	FCM Rate	$63.60	$64.87	$66.17	$67.49	$68.84	$70.22	$71.62	$73.06	$74.52	$76.01	$77.53
[7]	Peak Reduction Effectiveness	83.33%										
[8]	RNS Avoidance Benefit	$0	$0	$191,250	$200,162	$209,490	$219,252	$229,469	$240,162	$251,354	$263,067	$275,326
[9]	LNS Avoidance Benefit	$0	$0	$14,739	$15,034	$15,334	$15,641	$15,954	$16,273	$16,599	$16,930	$17,269
[10]	FCM Avoidance Benefit	$0	$0	$93,740	$95,615	$97,527	$99,478	$101,467	$103,497	$105,567	$107,678	$109,831
[11]	Asset Deferral Benefit	$0	$532,545	$888,987	$861,210	$834,257	$808,067	$782,581	$757,748	$733,517	$709,624	$685,779
[12]	Total Benefits	$0	$532,545	$1,188,716	$1,172,021	$1,156,609	$1,142,438	$1,129,471	$1,117,680	$1,107,036	$1,097,299	$1,088,205
	Costs											
[13]	Rev Req 25-Yr Assets	$0	($417,760)	($702,460)	($676,885)	($651,921)	($627,522)	($603,646)	($580,253)	($557,308)	($534,612)	($511,952)
[14]	Rev Req 12/13-Yr Assets	$0	($286,209)	($482,281)	($444,210)	($413,030)	($384,434)	($357,776)	($334,994)	($314,150)	($293,306)	($272,463)
[15]	O&M	$0	0	($79,406)	($79,667)	($149,976)	($150,287)	($150,624)	($150,987)	($151,377)	($151,795)	($152,240)
[16]	Total Costs	$0	($703,969)	($1,264,146)	($1,200,762)	($1,214,927)	($1,162,243)	($1,112,046)	($1,066,235)	($1,022,836)	($979,713)	($936,655)
[17]	Net Benefit to All Customers	$0	($171,425)	($75,430)	($28,741)	($58,318)	($19,806)	$17,425	$51,445	$84,201	$117,586	$151,550
	Net Present Value Calculation											
[18]	After-Tax WACC	7.09%										
[19]	Net Present Value of Benefits	$11,855,322										
[20]	Net Present Value of Costs	($9,956,354)										
[21]	Net Present Value Customer (Cost)/Benefit	$1,898,969										
[22]	Cost/Benefit Ratio	**1.19**										

[1] Investment year
[2] Calendar year
[3] kW installed
[4] Based on ISO-NE forecast
[5] Based on historic payments
[6] FCA 11 clearing price grown at inflation
[7] Assumption of 10/12 peaks hit, consistent with 4-hour battery
[8] [4] * [3] * [7]
[9] [5] * [3] * [7]
[10] [6] * [3] * [7]
[11] Revenue requirement of traditional poles-and-wires solution
[12] [8] + [9] + [10] + [11]
[13] Revenue requirement of 25-year assets
[14] Revenue requirement of 12/13-year assets (lithium ion cells)
[15] Estimated operations & maintenance
[16] [13] + [14] + [15]
[17] [12] + [16]
[18] After tax weighted average cost of capital
[19] Net present value calculation of [12] using [18] as discount rate
[20] Net present value calculation of [16] using [18] as discount rate
[21] Net present value calculation of [17] using [18] as discount rate
[22] -[19] / [20]

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Inv Year 12	Inv Year 13	Inv Year 14	Inv Year 15											
2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
$203.40	$212.88	$222.80	$233.19	$244.05	$255.43	$267.33	$279.79	$292.82	$306.47	$320.75	$335.70	$351.34	$367.71	$384.85
$12.43	$12.68	$12.94	$13.19	$13.46	$13.73	$14.00	$14.28	$14.57	$14.86	$15.16	$15.46	$15.77	$16.08	$16.41
$79.08	$80.66	$82.27	$83.92	$85.60	$87.31	$89.06	$90.84	$92.65	$94.51	$96.40	$98.32	$100.29	$102.30	$104.34
$288,156	$301,584	$315,638	$330,347	$345,741	$361,853	$378,715	$396,363	$414,834	$434,165	$454,397	$475,572	$497,733	$520,928	$545,203
$17,614	$17,967	$18,326	$18,693	$19,066	$19,448	$19,837	$20,233	$20,638	$21,051	$21,472	$21,901	$22,339	$22,786	$23,242
$112,028	$114,269	$116,554	$118,885	$121,263	$123,688	$126,162	$128,685	$131,259	$133,884	$136,562	$139,293	$142,079	$144,920	$147,819
$661,933	$638,088	$614,243	$590,398	$566,553	$542,707	$518,862	$495,017	$471,172	$447,326	$425,245	$406,690	$389,899	$373,108	$356,317
$1,079,732	$1,071,908	$1,064,761	$1,058,322	$1,052,623	$1,047,696	$1,043,576	$1,040,298	$1,037,902	$1,036,426	$1,037,675	$1,043,456	$1,052,050	$1,061,742	$1,072,580
($489,293)	($466,633)	($443,973)	($421,313)	($398,653)	($375,993)	($353,333)	($330,673)	($308,013)	($285,353)	($264,001)	($245,264)	($227,834)	($210,405)	($192,975)
($251,619)	($230,775)	($242,737)	($222,605)	($205,249)	($191,173)	($178,327)	($166,403)	($156,323)	($147,167)	($138,010)	($128,853)	($119,696)	($110,539)	($101,382)
($152,714)	($153,216)	($83,725)	($87,326)	($144,858)	($145,780)	($146,735)	($147,723)	($148,744)	($149,799)	($150,888)	($152,013)	($153,174)	($154,372)	($155,607)
($893,625)	($850,624)	($770,435)	($731,243)	($748,760)	($712,946)	($678,395)	($644,799)	($613,081)	($582,319)	($552,899)	($526,130)	($500,704)	($475,316)	($449,964)
$186,107	$221,284	$294,326	$327,079	$303,863	$334,749	$365,180	$395,499	$424,821	$454,107	$484,776	$517,326	$551,346	$586,426	$622,616

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2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056
$402.78										
$16.73										
$106.43										
$570,609	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
$23,707	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
$150,775	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
$339,526	$ 322,734	$ 305,943	$ 289,152	$ 272,361	$ 255,570	$ 238,779	$ 221,988	$ 205,197	$ 188,405	$ 90,005
$1,084,617	$322,734	$305,943	$289,152	$272,361	$255,570	$238,779	$221,988	$205,197	$188,405	$90,005
($92,130)										
($48,402)										
($156,881)										
($297,413)										
$787,204	$322,734	$305,943	$289,152	$272,361	$255,570	$238,779	$221,988	$205,197	$188,405	$90,005

MEMORANDUM OF UNDERSTANDING

THIS MEMORANDUM OF UNDERSTANDING ("MOU") is entered into this 13th day of May 2019, between the University of New Hampshire ("UNH"), a component institution of the University System of New Hampshire and Public Service Company of New Hampshire d/b/a Eversource Energy ("Eversource"), having a principal address of 780 North Commercial Street, Manchester, NH 03101, UNH and Eversource are collectively (the "Parties"). Eversource and UNH may be collectively referred to herein as "the Parties".

WHEREAS, UNH is committed to the advancement of sustainable and renewable energy that balances the values of environmental stewardship, social responsibility, and economic vitality;

WHEREAS, Eversource is committed to increase resilience, reliability, environmental sustainability and security of the electric distribution system serving the University of New Hampshire and critical loads in the surrounding Town of Durham area;

WHEREAS, UNH and Eversource are parties to a Memorandum of Understanding dated March 1, 2019 pursuant to which they are collaborating on energy efficiency initiatives aimed at reducing UNH's energy consumption and greenhouse gas emissions;

WHEREAS, the Parties wish to advance the body of knowledge with respect to community microgrid development and implementation by providing an island of continuous local energy supply during a power outage;

WHEREAS, the Parties intend to develop a demonstration pilot project to be known as the Oyster River Microgrid Project utilizing the Parties' infrastructure to serve campus and community load ("Project");

NOW, THEREFORE, in consideration of the Parties' goals and objectives, UNH and Eversource hereby agree as follows:

1. Definitive Agreement. The Parties intend to enter into negotiations toward a definitive agreement to implement the objectives of this MOU, including without limitation terms governing ownership, access, and control of assets constructed or utilized in the implementation of the Project ("Definitive Agreement"). Such Definitive Agreement is subject to approval by duly authorized representatives of the Parties, in their sole discretion.

2. Term and Termination. The term of this MOU shall commence as of the Effective Date and shall end on the earlier of (a) the date the Parties enter into a Definitive Agreement implementing this MOU or (b) thirty days following the date on which a Party provides written notice of its intent to terminate this MOU ("Term").

3. Key Principles. The Definitive Agreement shall incorporate the following principles:

(a) The Project will aim to lower the total annual cost of energy for microgrid customers and/or add value for resiliency and sustainability;

(b) The Project will be implemented in a manner consistent with Eversource's franchise and shall not adversely impact the respective rights and obligations of the Parties;

(c) UNH shall retain all rights and obligations as detailed by existing UNH Research Policies set forth by the University System of New Hampshire (https://www.usnh.edu/policy/unh/viii-research-policies);

(d) Eversource shall own any distribution infrastructure up to the customer meters;

(d) Eversource shall own and operate any microgrid control infrastructure required to ensure load and generation are balanced in the island configuration;

(e) Eversource shall operate the microgrid in the island configuration to ensure service reliability and resiliency drawing upon its expertise as a distribution service provider;

(f) Eversource and UNH will develop mutually agreed upon operating procedures to govern the use of each Party's assets, which operating procedures shall be incorporated into the Definitive Agreement;

(g) UNH shall have the ability to control its behind-the-meter assets consistent with its current operating guidelines when the microgrid is not in the island configuration;

(h) UNH has the right to add UNH-owned assets to the microgrid behind its meter;

(i) Eversource would own and maintain front-of-the meter solar or energy storage resources interconnected to the microgrid distribution infrastructure used to help balance load and generation in the island configuration;

(j) Microgrid costs allocated to all customers should reflect resiliency benefit for multiple users in the area (community and UNH); benefits accruing to a single customer should be allocated to that customer alone;

(k) The Parties shall collaborate with one or more representatives of the Town of Durham with respect to incorporating off-campus community load in the Project;

(l) Energy efficiency and demand response opportunities may be explored as part of a project design; and

(m) The Parties shall establish a shared decision-making process with respect to Project design, including Project capabilities and assets.

4. Funding. Eversource intends to seek cost recovery for the proposed Project in its upcoming rate case through a resiliency tracker to include costs associated with solar, storage, distribution and microgrid controller. The Parties shall work together to seek other available sources of funding, including without limitation potential funding available through the Department of Energy.

5. Communications. The Parties shall work together to develop a communications plan to promote the Project and the Parties' collaboration under this MOU. UNH agrees to give appropriate credit to Eversource for its financial support in all press releases, publications, annual reports, video credits, dedications, and other public communications regarding this MOU. The Parties agree not to issue any press releases, publications, annual reports, video credits, dedications, or other public communications regarding this MOU or any of the projects associated with this MOU without having received approval in advance from the other Party.

6. Key Personnel, Regular Meetings.

   (a) *Executive Sponsors*. The Parties' respective executive sponsors, named below, shall meet no less than biannually throughout the Term.

UNH:

James W. Dean, Jr.
President, University of New Hampshire
Thompson Hall
105 Main Street
Durham, NH 03824
(603) 862-2450
James.Dean@unh.edu

Eversource:

William J. Quinlan
President PSNH
Eversource Energy
780 N. Commercial Street
Manchester, NH 31001
(603) 634-2761
william.quinlan@eversource.com

(b) *Party Representatives*. Representatives for each of the Parties, named below, shall meet no less than quarterly throughout the Term.

UNH: Kevin Gardner
Vice Provost for Research, University of New Hampshire
Thompson Hall
105 Main Street
Durham, NH 03824
(603) 862-4334
Kevin.Gardner@unh.edu

Eversource: Jennifer Schilling
Director, Grid Modernization
Eversource Energy
107 Selden Street
Berlin, CT 06037
(860) 665-6523
jennifer.schilling@eversource.com

7. Miscellaneous.

(a) *Amendments*. This MOU may be amended only by the mutual written agreement of the Parties.

(c) *No Assignment*. Neither Party may assign this MOU, in whole or in part, to any individual or other legal entity without the prior written approval of the other Party.

(d) *Notices and Reports*. All notices and reports required or permitted to be given under this MOU shall be in writing and shall be deemed given when delivered personally or by any of first-class mail (postage prepaid), overnight mail delivery by a nationally known courier and addressed to the Party Representatives identified in paragraph 6, or certified or registered mail, return receipt requested, postage prepaid. All notices and reports may be sent by e-mail, but any financial and programmatic reports must be provided in hard copy as well. Each Party agrees to notify the other within ten (10) business days after any change in named executive sponsors and representatives, address, telephone, or other material contact information.

(e) *Entire MOU*. This MOU constitutes the entire agreement between the Parties and supersedes all prior and contemporaneous agreements, representations or understandings, if any, whether written or oral.

(f) *Severability*. If any provision of this MOU is deemed invalid or unenforceable by a Court of competent jurisdiction, the remaining provisions shall continue in full force and effect to the extent they can be lawfully effectuated.

IN WITNESS WHEREOF, the Parties have caused this MOU to be executed, by their duly-authorized representatives, intending to be legally bound by all the provisions of this MOU.

PUBLIC SERVICE COMPANY OF NEW HAMPSHIRE d/b/a EVERSOURCE ENERGY	UNIVERSITY OF NEW HAMPSHIRE
By: [signature] 5/16/19	By: [signature] 5/17/19