RESILIENT POWER PROJECT CASE STUDY

STERLING MUNICIPAL LIGHT DEPARTMENT

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RESILIENTPOWER

A project of Clean Energy Group

RESILIENT POWER PROJECT CASE STUDIES

This case study is one in a series by Clean Energy Group (www.cleanegroup.org) as part of The Resilient Power Project (www.resilient-power.org), a joint project with Meridian Institute (www.merid.org). This project seeks to expand the use of clean, distributed generation for affordable housing and critical community facilities to avoid power outages; to build more community-based clean energy systems; and to reduce the adverse energy-related impacts on vulnerable populations. The case studies produced seek to highlight installations of solar PV and battery storage (solar+storage) systems to demonstrate their economic, community resiliency, and health benefits. More information about this project and others can be found at www.resilient-power.org.

ACKNOWLEDGEMENTS

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Sterling, Massachusetts

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LEARN MORE

Report: The Value Proposition for Energy Storage at the Sterling Municipal Light Department (Sandia National Laboratories, 2017):

www.cesa.org/resource-library/resource/the-value-proposition-for-energy-storage-at-the-sterling-municipal-light-department

Video: Sterling Municipal Light Department Energy Storage System – A Revolution for the Electric Grid (Clean Energy Group/ Clean Energy States Alliance, 2017):

https://youtu.be/w3It2lwLCm4

Energy Storage Procurement Guidance Documents for Municipalities (Sandia National Laboratories, Clean Energy Group, and Clean Energy States Alliance, 2016):

www.cesa.org/resource-library/resource/energy-storage-procurement-guidance-documents-for-municipalities

For more information and resources related to the Sterling energy storage project, including webinars, fact sheets and reports, visit Clean Energy Group's featured project page:

www.cleanegroup.org/ceg-projects/resilient-power-project/featured-installations/sterling

Sterling Municipal Light Department Energy Storage System

A small municipal utility installed a battery storage system to compliment an existing solar electric system for cost savings and resilient power

THE CHALLENGE: Variable Solar and Increasing Costs

Sterling Municipal Light Department (SMLD) is a municipal utility serving the small New England town of Sterling, Massachusetts, with 3,700 residential, commercial, municipal and industrial customers. In 2013, with a total of 3.2 megawatts (MW) of solar PV installed, SMLD became the number one utility in the country for solar watts per customer. Solar accounted for approximately 30 percent of SMLD's peak load. At this high level of penetration, the variable nature of solar generation began to cause problems. Additionally, the costs of capacity and transmission services, based on SMLD's peak demand for power purchased from the grid operator, were rising dramatically. These costs increased from $500,000 in 2010 to $1.2 million in 2017. SMLD needed a new strategy to firm the output of its solar generation and control rising costs linked to the utility's share of regional demand peaks.

THE SOLUTION: Solar PV plus Battery Storage System

The Town of Sterling was considering adding a natural gas peaker plant to avoid rising capacity costs at its Municipal Light Department. But this idea was abandoned when the option of energy storage presented itself in the form of a state grant program offered through the Massachusetts Department of Energy Resources (DOER), called the Community Clean Energy Resiliency Initiative (CCERI). The grant program, initiated after Superstorm Sandy devastated the Northeast, was designed to support municipal resilient clean energy systems. The town had also been hit by an ice storm in 2008, which had left residents without power for up to 14 days; thus, resiliency had been a longtime concern for the town. Energy storage presented an attractive means to firm the town's solar resources, add resiliency for critical infrastructure, and control rising costs.

A 2-MW, 3.9-megawatt-hour (MWh) lithium-ion battery storage system was installed at SMLD's Chocksett Road Substation in October 2016. (See Appendix A for the project timeline.) The system is designed to "island" from the grid during a power outage and, with the support of an existing 2 MW of solar generation, will be able to provide at least 12 days of backup power to the town's police station and dispatch center, a critical facility providing first responder services. The substation, the solar field, and the police department are all on the same electrical feeder, which can be isolated to create a microgrid in the event of a grid outage.

A 2017 report by Sandia National Laboratories (The Value Proposition for Energy Storage at the Sterling Municipal Light Department) analyzed the economic case for Sterling's battery system. The analysis indicates that the payback period for the system will be 2.5 years, and would be less than 7 years without grant funding.

Over its first year of operations, the battery system has proven this strong economic case. By storing electricity from the solar panels during sunny days and from the grid during low-cost times, such at night, the batteries can make inexpensive electricity available during peak demand times when electricity is more expensive. Discharging the batteries during periods of regional peak demand also reduces SMLD's transmission and capacity payments to the regional transmission operator, ISO New England (ISO-NE). These savings combined amount to approximately $400,000 per year.

The entire energy storage project is comprised of several major systems: the containerized battery system, a power conversion system, and a controls system.

Connected to the energy storage system is a step-up transformer, which matches the voltage output of the energy storage system to that of Sterling's utility system. The auxiliary power system provides power to the battery container HVAC and fire protection systems. Finally, the data connection system provides two-way communication to the energy storage controls system, the operator for remote operation, and the remote monitoring system. These are all described in more detail below, along with the fire suppression and cooling systems.

Project Overview

Owner: Sterling Municipal Light Department

Location: Chocksett Road Substation, Sterling, MA

Equipment: 2.2 MW / 3.9 MWh lithium-ion battery, installed on feeder with existing 2 MW solar electric system

Installed cost: $2.52 million

Payback: 6.3 years (2.5 years after accounting for grant funds)

Building loads supported: Full operation of police station and emergency dispatch center

Services provided: Annual capacity and monthly transmission cost management, energy arbitrage, , backup power

Supported infrastructure: Police station and dispatch center for emergency response

Battery vendor: NEC Energy Solutions

Project partners: Sterling Municipal Light Department, Massachusetts Department of Energy Resources, U.S. Department of Energy Office of Electricity, Sandia National Laboratories, Clean Energy Group, Clean Energy States Alliance, and Barr Foundation.

Solar System Details

Solar system size: 2 MW (pre-existing)

Configuration: Ground-mounted

Estimated annual production: 1,526,000 kWh

Ownership structure: Power Purchase Agreement

System owner: TerraForm Power

Revenue sources: Resale of energy (kWh)

Energy Storage System Details

Type of technology and size (power-kW / capacity-kWh): 2-MW/3.9-MWh lithium-ion battery installed in 40 racks within a metal container that includes all controls and other associated hardware, plus cooling and fire suppression systems

System location: Outdoor containerized system

Container size: 53′ x 8.5′ x 9.5′

Owner: Sterling Municipal Light Department

Provider: NEC Energy Solutions

Date of service/operation: December 2016

Revenues sources: Annual peak capacity reduction, monthly transmission peak reduction, energy arbitrage

Containerized system. The batteries are installed as a racked system within a metal shipping-type container that includes all associated equipment and controls to operate the batteries. The 2.2-MW inverter is located adjacent to the container. The design of the battery container is integrated with thermal management in the form of rooftop-mounted HVAC systems that provide climate control for the batteries. The container also contains an automated fire suppression system using a gaseous agent designed to suppress a fire by removing heat.

Step-up transformer. Sterling provided this transformer to integrate the containerized battery system into the existing SMLD grid. Located between the inverter and the incoming feeder interconnection, the step-up transformer converts 480V AC output from the battery's inverter to 13.8 kV AC, matching Sterling's AC distribution voltage level.

Auxiliary transformer. To bring power to the battery system, a distribution feed (electrical line) was connected from a circuit immediately outside of the substation to a utility pole within the substation. This line was brought into a 2,500-kVa pad-mounted transformer; this was then loop-fed to the 75-kVa auxiliary transformer, and the two separate feeds, one for the auxiliary power, was connected to the battery container. This provides power to the cooling and fire suppression systems within the container that houses the battery racks. The auxiliary load for HVAC and lights averages about 135 kWh/day. The other circuit is the main circuit for the batteries when they are being charged or discharged.

Battery data access and dispatch. A multi-mode fiber cable runs from the Sterling substation control house to the software system, NEC Energy Solutions Advanced Energy Response Operating System (AEROS), within the battery container. This fiber optic cable provides communication of information, like voltage and current measurements, from the interconnection point to the controls for the battery, allowing SMLD to receive real time information and perform diagnostic and programming functions. AEROS provides command and control functionality ranging from a simple dispatch mode, where the system responds to external power commands, to complex autonomous modes based on dispatch control set points. In each of the available modes of operation, AEROS manages system power, battery state of charge, and internal conditions related to availability, safety, and life of the battery system. The AEROS Master Controller manages the complete system including battery zones (through the zone controllers) and power conversion systems.

Initially, SMLD controlled the battery using the AEROS system. However, in order to increase efficiency, Massachusetts Municipal Wholesale Electric Company (MMWEC) has now taken over dispatch responsibilities for the battery. MMWEC has been given full access to AEROS to monitor and operate the battery system remotely, and intends to offer similar services to other municipal utilities in the state.

Energy Storage System Economics

Total Installed Costs: $2,520,000

Grants Received:

- **MA DOER CCERI Grant:** $1,463,194
- **U.S. DOE-OE Grant:** $250,000

Breakdown of Year-One Savings:

- **Capacity Savings**: $240,660
- **Transmission Savings**: $145,671
- **Energy Arbitrage:** $12,567
- **Total Year-One Savings**: $398,898

Anticipated Payback Period:

- **With Grants**: 2.5 years
- **Without Grants**: 6.3 years

FINANCIAL DETAILS

Project costs and grant funding. The total installed cost of the project was $2.52 million. The Massachusetts DOER CCERI grant was $1.465 million, and the project received an additional $250,000 from the U.S. Department of Energy Office of Electricity (DOE-OE) through the Energy Storage Technology Advancement Partnership (ESTAP), an initiative of DOE-OE, Sandia National Laboratories and the Clean Energy States Alliance (CESA) to leverage public-private funding for energy storage deployment. SMLD paid for the remainder of the project cost. The additional DOE-OE funding enabled SMLD to increase the size of the battery from 1 MW to 2 MW to enhance energy cost savings; having more storage capacity allows SMLD to discharge energy over longer periods of time, increasing the opportunity to capture monthly and annual peak periods where the exact timing is difficult to forecast. The project also received technical assistance from Sandia, CESA, and Clean Energy Group with funding from Barr Foundation.

The Economic Case for Energy Storage. A key benefit of the project was to demonstrate and analyze the economic case for the batteries, and to identify potential benefits and value streams from electrical energy storage. A white paper analysis, "The Value Proposition for Energy Storage at the Sterling Municipal Light Department," was completed in early 2017, led by DOE-OE and Sandia. Economic benefits considered in this analysis include: energy arbitrage, frequency regulation, reduction in monthly network load, reduction in capacity payments to ISO New England, and grid resiliency. Based on this analysis, SMLD expects the battery to produce at least $400,000 per year in cost savings over the project's 10-year lifespan, which is a significant for a small municipal utility with an annual budget of $8.2 million. In the first year of operations, cost savings came within $1,100 of the $400,000 annual projection.

The battery was commissioned in December 2016. Projected and actual savings, where available, are given below. The economic case proven by SMLD's battery system has attracted the notice of other municipal utilities and electric cooperatives in New England, several of which are planning to install their own battery systems.

Energy arbitrage savings

The Sandia report found energy arbitrage—charging the battery when electricity prices are low and discharging the battery when electricity prices are high—to have a potential value of $13,321 per year for a 1-MW/1-MWh battery system. Since the installed battery capacity of this project is 2 MW/3.9 MWh, the actual revenue potential is expected to be higher. During its first 12 months of operation, the energy storage system provided $12,567 in arbitrage savings.

Frequency regulation revenues

SMLD does not plan to participate in frequency regulation—a grid-balancing service that batteries can be paid for providing to ISO-NE. The Sandia report valued this service at $60,476 per year for a 1-MW/1-MWh battery, but potential revenues from this service would be significantly higher for SMLD's larger energy storage system.

Regional network service savings

Significant cost savings for SMLD can be achieved by using the batteries to reduce transmission charges

(Regional Network Service charges). These charges are assessed based on a single peak demand hour each month. If the utility reduces demand during the monthly regional peak, it reduces its share of transmission costs for that month. The Sandia report showed this potential revenue stream to be the second highest for SMLD, valued at $98,707 per year for a 1-MW/1-MWh battery. In its first 12 months of operation, the battery enabled Regional Network Service charge savings of $145,671.

Forward capacity market savings

The Sandia report showed the biggest energy cost savings potential from the batteries comes from reducing Sterling's electricity demand during a single annual peak demand hour for the ISO New England region. This is valued at $115,572 per year (2017-2018 pricing) for a 1-MW/ 1-MWh battery, and roughly twice that amount for SMLD's larger battery. This regional peak demand hour generally occurs during the summer, and each utility in New England is assessed an annual fee for capacity services based on its individual contribution to demand during that one-hour period. In 2017, SMLD discharged its system during the annual peak on June 13 and realized a savings of $240,660.

Capacity prices are established in a three-year forward auction, and will be higher next year, meaning the potential for capacity savings will increase. Rising capacity and transmission costs were a primary reason for SMLD's investment in energy storage. However, capacity prices can also decrease. Savings from this use of the energy storage system will rise and fall depending on the price of capacity in any given year.

Resilience savings

This revenue stream cannot presently be monetized, and is difficult to estimate, since it depends on the severity of future extreme weather events and grid outages. With several assumptions, the Sandia report valued this benefit at $40,819 per grid outage event. This calculation was based on the value of lost services due to grid disruptions for a typical commercial customer and did not account for improved public safety or health, which the SMLD system will provide by supporting the town's police and dispatch services. Since SMLD's battery is providing backup power to critical services, the potential value of resilience services could be significantly greater.

Renewables integration benefits

While the value of this benefit is difficult to quantify, it is nevertheless an important one, particularly where variable resources supply a significant portion of the local generation portfolio. In the case of SMLD, approximately 35 percent of generation comes from renewable sources. Prior to the installation of the energy storage system, SMLD had declared a moratorium on additional variable generation, due to concerns about potential for back-feed of power onto the transmission system. Because the battery can buffer the system, as well as contributing to grid stability and reliability by providing voltage support to variable power sources like wind and solar, SMLD can now consider adding more variable renewable generation to its grid.

Based on the success of their Chocksett Road Substation installation, SMLD is currently working on a new energy storage project in conjunction with a community solar installation.

LESSONS LEARNED

Some key lessons were learned during the installation of Sterling's energy storage system.

Creating procurement guidelines. At the time when Sterling was seeking vendor proposals, there were no procurement guidelines to look at for guidance in developing a Request for Proposals (RFP) for a resilient energy storage system that would provide grid services. As a result, the technical team, comprised of SMLD and its engineer team including PLM and Reynolds Engineering LLC, Sandia National Laboratories, and CEG/CESA with its contractor, Bright Power, worked together to develop procurement documents. These documents were then expanded into a set of model procurement guidelines to serve as a template for municipalities developing similar projects (see Energy Storage Procurement Guidance Documents for Municipalities).

Evaluating emerging technology. The project design team wished to receive proposals for both commercialized as well as emerging energy storage technologies. To evaluate both categories consistently, despite potential differences in the availability of performance data for different storage technologies, the team designed a three-tiered scoring system that allowed for comparison of the proposals against the components of the project that were most important to Sterling's decision makers (see Appendix C).

Compensating for battery degradation. It was important to Sterling that the battery system would have 3 MWh of functional capacity remaining at the end of its 10-year performance warranty (accounting for degradation over time). To achieve this, rather than the project design team specifying a capacity for the new battery, vendors were asked to conduct their own degradation calculations in their RFP responses, working backwards from the end goal to determine the needed capacity at the beginning of life. This was important, since each technology and product has its own life-cycle considerations and degradation rates under various operating conditions. Each of the vendors supplied their recommended sizing, based on the requirement of 3 MWh remaining at end of life, and the cost for that capacity. This allowed the project team to determine the best value based on the overall cost and degradation curve presented. The winning bidder provided a capacity assurance plan that guaranteed battery capacity to be at or above 3 MWh after 10 years; the delivered product was sized to 3.9 MWh to ensure the required performance over time.

Keeping costs down. In order to reduce installed costs, SMLD's line crew did much of the interconnection electrical work to connect the battery system to the substation. This also allowed SMLD to learn more about the battery system. Further cost cutting and improved efficiency was achieved by allowing the battery system to be remotely dispatched by the Massachusetts Municipal Wholesale Electric Company (MMWEC), which serves municipal utilities in Massachusetts. MMWEC already had a control center staffed around the clock, with operators trained to watch ISO-NE and weather alerts and dispatch renewable generators such as wind farms; allowing them to take over daily operations of the battery relieved SMLD of staffing costs and helped to ensure that critical demand peaks would not be missed by battery operators. MMWEC is now preparing to offer a similar service to the other municipal utilities in the state.

Technical assistance. In addition to hired contractor Reynolds Engineering, the support of Sandia, DOE-OE and CEG/CESA helped SMLD's decision makers navigate project design and technology selection. This was critical to the project's success. Although battery technology is maturing quickly, there is not much information available to the public about similar projects. While state grant funding supported project feasibility and engineering work, there was significant need for technical assistance to develop the project concept and economics before SMLD could move into the procurement phase.

Fire safety. SMLD's General Manager chose to involve the town's fire department from the beginning of this project to proactively address their concerns and prepare a training program to educate them about the energy storage system. NEC Energy Solutions, the battery vendor, also provided instructions and a more detailed presentation to first responders so they could understand the nature of the potential fire hazard. The fire department will be receiving additional specialized training at the substation. The site was also selected by Pacific Northwest National Laboratories for a regional training session on relevant codes and safety, which was held in Sterling in October 2017. It was attended by code officials and first responders from around the region.

APPENDICES

A. Project Timeline
B. SMLD's Three-Tiered Proposal Evaluation System
C. An Example of System Operation to Meet Demand Peaks
D. Photos

APPENDIX A: PROJECT TIMELINE

In total, the project took 2.5 years to develop from concept to construction; however, the installation itself moved very quickly with a groundbreaking in October 2016 and commissioning in December 2016.

Much of this 2.5-year period was spent in proposal and contract development between SMLD and MA DOER. Grant funding was sought from DOER's Community Clean Energy Resiliency Initiative, but was denied in the first round of funding, then awarded in the second round. The grant was awarded to the Town of Sterling and the grant was administered by the Sterling Municipal Light Department. It took one year to finalize the funding contract between MA DOER and the Town of Sterling. The delays due to multiple applications and time spent in contract negotiations between SMLD and the state inadvertently improved project economics, because battery costs declined significantly between the initial application and final project procurement.

April 2014	First application for $2.8 million (denied)
December 2014	Second application for $1.465 million (awarded)
October 2015	Contract signed with DOER
Oct 2015-April 2016	Hired OPM (Owner's Project Manager) and design engineers
Jan 2016-March 2016	Created an RFP that received 32 requests for project packages, seven responses with four finalists, selected NEC Energy Solutions
August 12, 2016	Contract with NEC Energy Solutions signed, equipment placed on order
October 12, 2016	Groundbreaking ceremony; foundation in, trenching completed
November 14, 2017	Site ready for equipment, equipment delivered, and placed
December 8, 2016	Installation complete
December 16, 2016	First operational cycle completed
April 2017	Microgrid functional test completed

APPENDIX B: SMLD's Proposal Evaluation Score Card

The project design team wished to receive proposals for both commercialized as well as emerging energy storage technologies. To evaluate both categories consistently, despite potential differences in the availability of performance data for different storage technologies, the team designed a three-tiered scoring system that allowed for comparison of the proposals against the components of the project that were most important to Sterling's decision makers.

Item 1 - Experience in high / medium voltage substation design

Score	Decryption of example qualifications
0-3	Respondent has little experience in substation design, does mostly industrial and commercial work for non-utility customers
4-6	Respondent does medium voltage distribution substation design work replacing transformers or breakers for instance. Respondent has done medium voltage substation design work for utilities the past.
7-10	Respondent's main business is performing high and medium voltage substation design work. Respondent provides several example projects where they have done breaker replacements, cap bank additional and transformer replacements in existing substations integrating new equipment with older existing equipment. Respondent has several repeat utility scale customers.

Item 2 - Experience in SCADA design

Score	Decryption of example qualifications
0-3	Respondent has not used SEL 2030 SCADA equipment in the past and does not demonstrate a technical understanding of the work required
4-6	Respondent has some basic understanding of RTUs and has an electrical engineer on staff who performs SCADA work on part time basis when needed.
7-10	Respondent has a full time SCADA engineer on staff who would be assigned this portion of the project. The engineer is well versed in SEL data concentrator setup and configuration and has experience with the SEL-2030 model. The respondent asks intelligent questions regarding the remote connection from SMLD to the data concentrator.

Item 3 - Experience in Relaying and protection coordination and power systems studies

Score	Decryption of example qualifications
0-3	Respondent is not well versed in relay coordination, load flow and arc flash studies and does not provide evidence that they have successfully performed these types of studies for other customers in the past.
4-6	Respondent has only performed arc flash studies and simple overcurrent relay and fuse coordination studies for radial systems.
7-10	Respondent has a full-time protection engineer who will be assigned to perform this part of the project. Relay settings for high voltage substations are demonstrated to be a regular part of the respondent's services provided to repeat utility customers. The respondent asks intelligent questions about the auto transfer scheme and how a source on the low side may affect its operation.

Item 4 - Experience with electro mechanical relay settings

Score	Decryption of example qualifications
0-3	Respondent has not done any work involving electromechanical relays and expresses concerns over how to model the elements in the protection software.
4-6	Respondent has done some work with electromechanical relays and is familiar with how to model the relay elements required in the protection coordination software.
7-10	Respondent demonstrates experience in performing relay coordination studies for high and medium voltage substations using electromechanical relays for repeat utility customers.

Item 5 - Experience on generation interconnection projects

Score	Decryption of example qualifications
0-3	Respondent's work does include substation upgrades but respondent has done little or no substation integration work for a generation source.
4-6	Respondent has done some work on the utility side working with generators integrating sources of electric power to existing substations. Respondent has seen control systems integrated for distributed generation sources from the utility perspective.
7-10	Respondent demonstrates experience integrating distributed generation sources such as wind, solar, or battery storage at the medium voltage substation level. Respondent has worked directly for distributed generation developers on such projects. Respondent demonstrates multiple projects experiences integrating controls systems, alarms and SCADA systems for distributed generation resources.

Item 6 - Experience on battery or inverter based projects

Score	Decryption of example qualifications
0-3	Respondent has not done a project that integrates a battery system or a solar system using an inverter. Respondent may have done some small commercial solar integration on the sub-utility scale level.
4-6	Respondent has done some utility scale solar integration connecting large inverters to the medium voltage utility system where the POI is at medium voltage. Respondent has not done a utility scale battery integration project.
7-10	Respondent provides project experience integrating a Utility scale battery project at a medium voltage utility substation or on a distribution system.

Item 7 - Proximity to Sterling, MA

Score	Decryption of example qualifications
0-3	Respondent's project manager/lead engineer sit further than a 4-hour drive from Sterling, MA
4-6	Respondent's project manager/lead engineer sit further than a 1-hour drive from Sterling, MA
7-10	Respondent's project manager/lead engineer sit closer than a 1-hour drive from Sterling, MA

Item 8 - Schedule proposed

Score	Decryption of example qualifications
0-3	Respondent does not include a proposed schedule. Schedule proposed is obviously far too short or too long and does not demonstrate a clear understanding of the scope of work or demonstrates that the respondent is too busy to dedicate resources to the project.
4-6	Respondent includes a realistic schedule of roughly 6 months for the complete engineering process. The schedule is well thought out and includes a list of information that the firm will need upfront to meet the schedule.
7-10	Respondent includes a realistic schedule of roughly 4 months for the complete engineering process. The schedule is well thought out and includes a list of information that the firm will need upfront to meet the schedule. Packages submittals to SMLD are broken out and review time for SMLD is included in the scheduled. Milestones of when information will be need form the battery manufacturer is included in the proposed schedule.

Item 9 - Understanding of the project based on RFP response

Score	Decryption of example qualifications
0-3	Respondent includes many exceptions in their proposal to exclude portions of the work that they do not understand or wish to take on. Statements in the proposal demonstrate a clear mis-understanding of the scope of work. Respondent obviously copies and pastes the scope of work from the RFP to their own proposal.
4-6	Respondent does not take any exceptions or include any clarifications in their proposal w/r/t the scope of work responsibility. This demonstrates a lack of understanding of the scope and a lack of thorough review of the project requirements.
7-10	Respondent organizes their proposal in a clear manner which demonstrates the services that will be performed. Respondent includes well thought out clarifications in their proposal which do not eliminate required deliverables from the respondent's scope. The clarifications are meant to demonstrate a thorough understanding of the scope. Respondent points out gaps that may be found in the RFP and offers additional services to fill such gaps.

Item 10 - Ability to self-perform all work

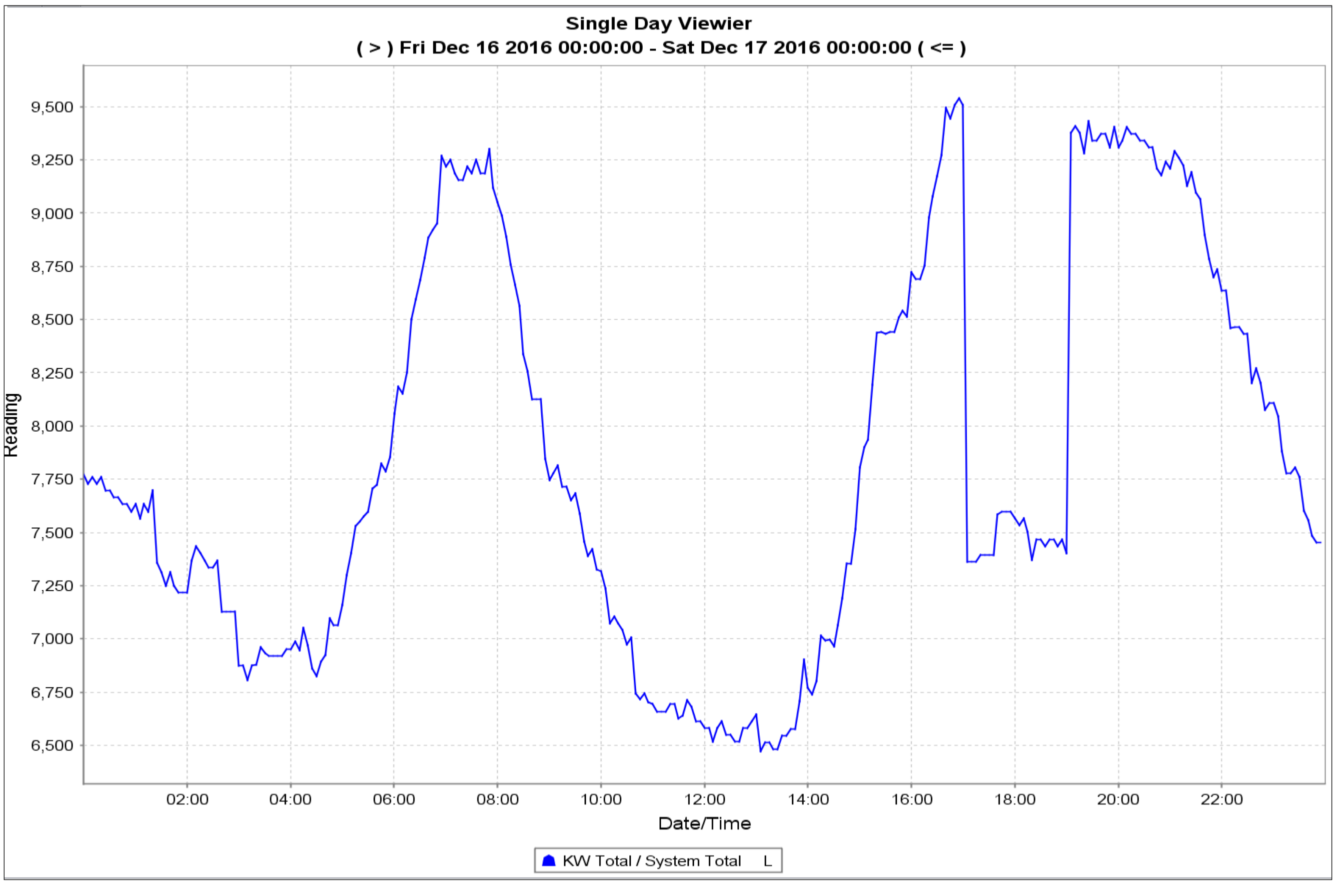
Score	Decryption of example qualifications
0-3	Respondent proposes to subcontract most of the work to casual employees or another firm. Respondent plans to only manage the work and not to perform the work with in-house employees. This demonstrates that the firm is too busy to take on the work.
4-8	Respondent plans to execute the majority of the work with in-house resources and plans to outsource the specialty work such as SCADA, relay settings and studies to an outside party or casual employees. The respondent demonstrates a consistent relationship with these outside parties and that this is part of the respondent's normal business practice.
9-10	Respondent plans on executing all aspects of the project with dedicated internal employees. The respondent provides resumes for internal employees whose skillsets completely cover the scope of expertise required for this project.

Item 11 - Interview Performance

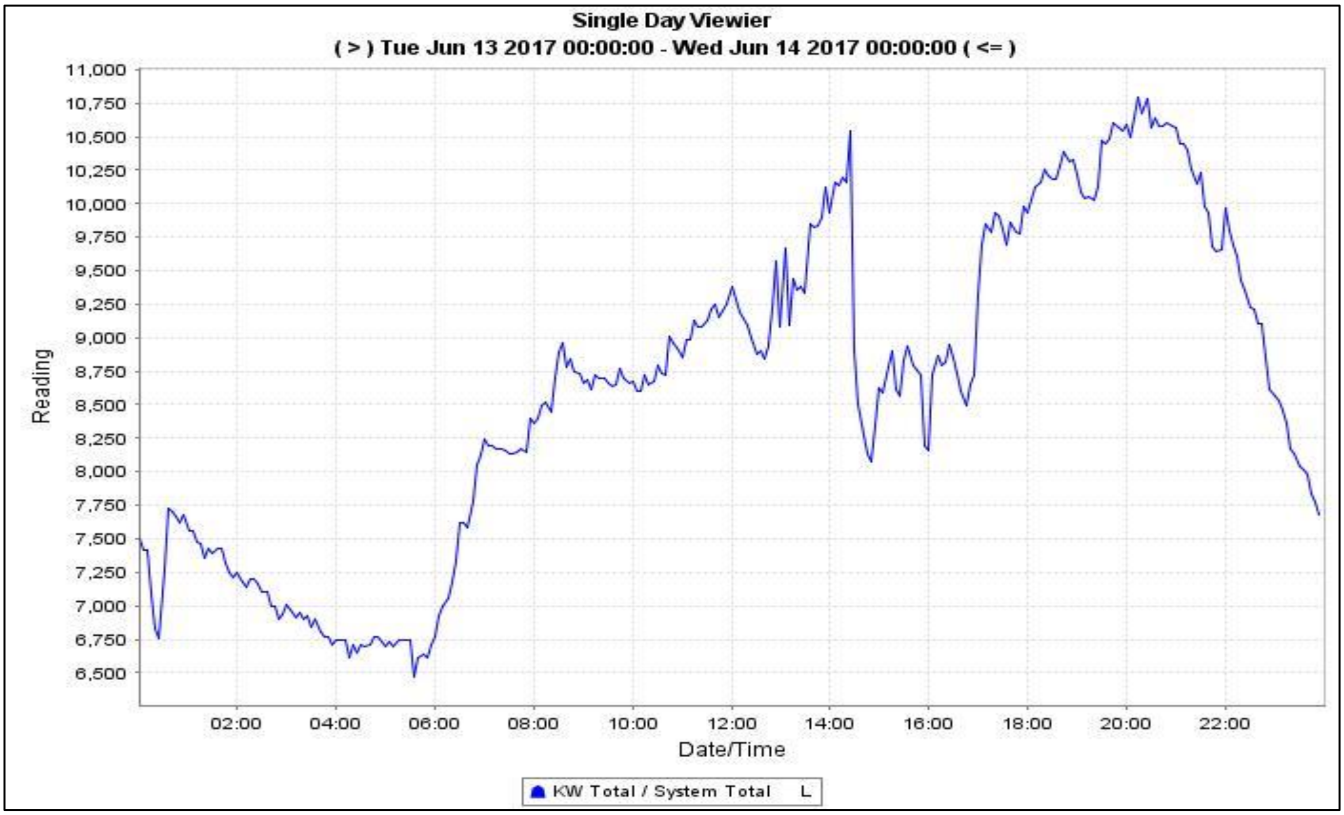
Score	Decryption of example qualifications
0-3	Respondent is not engaged and does not seem interested in working on the project.
4-6	Respondent may express concerns over resource loading. Respondent appears focused on their own interests instead of being a part of a successful project for SMLD.
7-10	Respondent is excited about the project and is truly interested in adding an ESS project to their experience list. Respondent brings up concerns to look out for that are in the best interest of SMLD. Respondent is interested to know when the project will kick off and how it will progress. The respondent has done some independent research on ESS projects and brings it up in the interview process for the benefit of SMLD.

APPENDIX C: Examples of System Operation to Meet Demand Peaks

This graph shows the first monthly discharge in December 2016 to meet the monthly peak, which occurred on December 17 between 5 pm and 7 pm. This two-hour discharge of the battery saved SMLD $17,000 in avoided transmission costs. These savings are available every month. This graph was provided by SMLD.



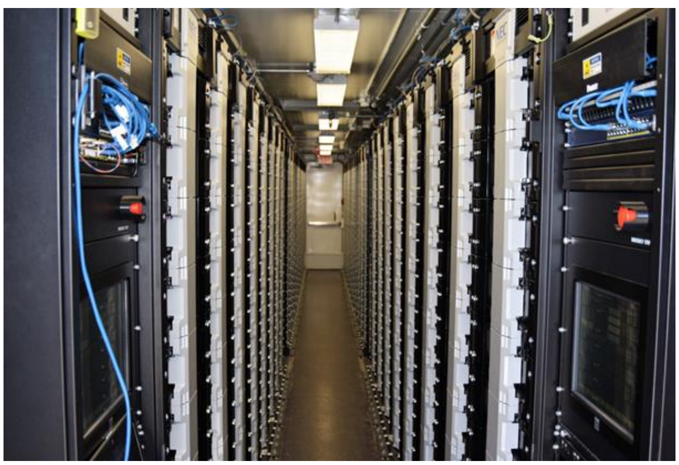
This graph shows the first use of the battery to reduce SMLD's annual capacity obligation by reducing its demand during the annual regional demand peak, in June 2017. This single use of the battery saved SMLD $240,660 in avoided capacity costs. This graph was provided by SMLD.



APPENDIX D: PHOTOS

Project partners pose for a photo at the groundbreaking event in Sterling, MA in October 2016. Left to right: Sean Hamilton (SMLD), Dan Borneo (Sandia), Roger Lin (NEC), Imre Gyuk (DOE), Todd Olinsky-Paul (CESA), Judith Judson (DOER), Doug Alderton (NEC). Photo by CESA.

Additional photos of the project groundbreaking event taken in October 2016 are available at: https://www.flickr.com/photos/cleanenergygroup/albums/72157684018743400



View inside the battery storage unit. Photo taken March 2017. Photo by Clean Energh Group.

Additional photos of the installed energy storage system taken in March 2017 are available at: https://www.flickr.com/photos/cleanenergygroup/albums/72157684018902160

View of the battery storage unit at the Chocksett Road Substation. Shown is the battery container, labeled NEC; the 2 MW inverter, in a separate white container; and two transformers. Photo courtesy of SMLD.

ABOUT THE RESILIENT POWER PROJECT

The Resilient Power Project, a joint initiative of Clean Energy Group and Meridian Institute, is working to accelerate market development of solar PV plus battery storage (solar+storage) technologies for resilient power applications serving low-income communities. The Resilient Power Project works to provide new technology solutions in affordable housing and critical community facilities to address key climate and resiliency challenges facing the country:

- **Community Resiliency** — Solar+storage can provide revenue streams and reduce electricity bills, enhancing community resiliency through economic benefits and powering potentially life-saving support systems during disasters and power outages.
- **Climate Adaptation** — Solar+storage systems can provide highly reliable power resiliency as a form of climate adaptation in severe weather, allowing residents to shelter in place during power disruptions.
- **Climate Mitigation** — Battery storage is an enabling technology and emerging market driver to increase adoption of solar PV for distributed, clean energy generation and to advance climate mitigation efforts.

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Learn more about the Resilient Power Project at
www.resilient-power.org.

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