AMERICAN PUBLIC POWER ASSOCIATION

Powering Strong Communities

PUBLIC POWER ENERGY STORAGE GUIDEBOOK

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The American Public Power Association thanks the member utilities and individuals who provided the information for the energy storage case studies in this document. Analysis and recommendations contained in this document were developed by Dr. Emmanuel Taylor and Christopher Kelley of Beam Reach Consulting Group under the guidance of Ji Yoon Lee, Carole Plowfield, and Dr. Paul Zummo of APPA, based on information provided by the following individuals:

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AMERICAN PUBLIC POWER ASSOCIATION
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About the American Public Power Association
The American Public Power Association is the voice of not-for-profit, community-owned utilities that power 2,000 towns and cities nationwide. We represent public power before the federal government to protect the interests of the more than 49 million people that public power utilities serve, and the 96,000 people they employ. Our association advocates and advises on electricity policy, technology, trends, training, and operations. Our members strengthen their communities by providing superior service, engaging citizens, and instilling pride in community-owned power.

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EXECUTIVE SUMMARY

This guidebook offers examples, insights, and recommendations for public power utilities and decisionmakers contemplating energy storage projects, including five case studies that explore energy storage projects implemented by public power utilities. It covers the purpose, value, and benefits of energy storage for public power, and includes common and divergent themes identified from the case studies.

This guidebook is designed to support stakeholders in the public power industry, including utilities, vendors, and utility customers. It provides information and best practices for planning, implementing, and managing energy storage projects, empowering readers to make informed decisions and explore energy storage options that align with their interests.

The case studies were developed through in-depth interviews with individuals involved in each project. This approach allowed for a thorough exploration of the projects, including objectives, benefits, challenges, and recommendations. The data collected from the interviews underwent qualitative analysis, employing techniques such as thematic analysis and content analysis to identify common themes and key findings.

Energy storage offers numerous value streams, including grid modernization, enhanced resiliency, renewable energy integration, support for electric vehicles, and cost savings. It provides public power utilities with greater control over energy supply and demand, contributing to grid reliability and a cleaner and more sustainable electricity delivery system.

The case studies highlight projects from different public power utilities, showcasing their objectives, benefits, and unique experiences. The projects address challenges such as peak load management, grid stability, renewable integration, cost savings, and emission reduction. The findings emphasize the importance of peak load flattening, regulatory and safety considerations, and the need for in-house and consulting expertise during project implementation.

The guidebook also covers additional considerations for energy storage projects, including common objectives and benefits, technological considerations, environmental impact, policy and regulatory context, and funding and support. While there are similarities among the projects, not all utilities pursued the same objectives or made identical decisions regarding scale, system ownership, or operation.

To implement their own energy storage projects successfully, public power utilities are encouraged to follow the suggested steps outlined in this guidebook. These steps include assessing deployment readiness, conducting feasibility studies, defining project objectives, identifying suitable technologies, assessing financing options, engaging stakeholders and building partnerships, developing comprehensive project plans, monitoring and evaluating performance, promoting public awareness and education, and continuously innovating and adapting to new advancements and trends in the energy storage sector.

By following these steps, public power utilities can leverage the benefits of energy storage, enhance grid reliability, integrate renewable energy sources, reduce emissions, and optimize their operations in an evolving energy landscape.

PURPOSE OF THIS GUIDEBOOK

This guidebook and the accompanying case studies are intended to provide public power utilities and decision makers with examples as they contemplate energy storage projects. Each of these use cases highlights challenges and opportunities that were addressed using energy storage. Through their experience, the participating member utilities have provided recommendations to follow and some potential pitfalls to avoid.

After reviewing this guide, readers will have new information about best practices for planning, implementing, and managing energy storage projects. Additionally, public power utilities that review this guidebook will be better prepared to explore energy storage options that will benefit their interests.

What Is Covered

This document explores five case studies covering unique energy storage projects implemented by public power utilities. The utilities represent various sizes, geographies and use cases for utility scale energy storage. Summaries of the case studies, together with a background on the purpose, value, and benefits of energy storage for public power are provided in this document. Additionally, common and divergent themes and recommendations are provided based on the collective experiences of the projects.

Intended Audience

This resource is for a variety of professionals across the public power sector, including individuals associated with utilities and vendors, who wish to learn more about utility-scale energy storage, its potential value and benefits, and the challenges and opportunities presented by storage projects.

These stakeholders include not only utility leadership, planners, and engineers, but also human resources, financial, legal, operational, and customer team members. Additionally, decision makers and managers at utilities, vendors that support public power utilities, and utility customers may find value in understanding the themes and recommendations found in this document.

METHODOLOGY

The case studies were developed based on in-depth interviews with individuals who had firsthand experience with each of the projects. Using an interview-based research approach, researchers carefully designed interview protocols to guide the conversation while remaining flexible enough to allow for in-depth exploration of relevant topics. Participants were asked to provide information about the project, including its objectives, benefits, what led to the success of the project, recommendations for best practices or improvements, and future opportunities for public power, the energy industry, and supporting government entities.

After the interviews were conducted, qualitative analysis techniques were employed to analyze the data. This involved transcribing and organizing the interview data, identifying themes and patterns, and extracting key findings. Researchers used various qualitative analysis methods, such as thematic analysis and content analysis, categorizing the data while comparing and contrasting different perspectives, and interpreting the findings in relation to the research objectives and existing literature.[1] Draft findings of each case study were reviewed with the respective member utilities originally interviewed, and final case studies were reviewed and approved by these members and their organizations.

This analysis was further refined in the development of this guidebook. Since some time passed between the initial development and final versions of the case studies, researchers revisited case studies with the member utilities to establish current findings. Collectively, the case studies were then analyzed to identify common and divergent themes together with recommendations that apply to public power utilities and others who wish to learn more about energy storage or are considering an energy storage project.

1 Additional research included findings from *Understanding Energy Storage: Technology, Costs, and Potential Value* (2017, APPA), *Behind-the-Meter Energy Storage: What Utilities Should Know* (2019, APPA), and *Public Power Energy Transition Roadmap* (2023, APPA).

ENERGY STORAGE FOR PUBLIC POWER

Purpose

Energy storage is a means for capturing energy at one point in time and reserving that energy for later use. This is useful for reducing imbalances between energy supply and demand and can be used to improve electricity reliability and lower overall electricity costs. At utility scale, energy storage solutions help address challenges posed by intermittent and distributed energy resources and can defer or eliminate more expensive infrastructure investments.

Value and Benefits

Energy storage solutions offer various value streams that can be derived from their deployment, depending on technologies, services, and regulatory environments. A 2022 report developed by APPA's Energy Storage Working Group explored potential benefits for deploying storage.[2] Examples of value streams explored in these case studies include:

- Contribution to grid modernization, enhanced resiliency, and the integration of increased renewable energy and distributed energy resources.
- Enabling the optimization of renewable energy generation and load flexibility, improving the overall efficiency and stability of the electric grid.
- Supporting the growth of electric vehicles by providing charging infrastructure and grid integration capabilities.
- Helping public power utilities meet low-emissions goals and transition to a cleaner and more sustainable electricity delivery system.
- Offering opportunities for cost savings, revenue generation, mitigation against peak demand charges, consumer engagement, and customer satisfaction.

Overall, energy storage provides public power utilities with greater control over energy supply and demand, enhancing grid reliability, and facilitating the integration of renewable energy resources while ensuring cost-effectiveness and meeting sustainability objectives.

2 Integrating Energy Storage Solutions for Fossil Fuel Generation: Value Propositions and Pathways for Public Power (2022, APPA), https://www.publicpower.org/resource/integrating-energy-storage-solutions-fossil-fuel-generation

PUBLIC POWER ENERGY STORAGE CASE STUDY SUMMARIES

The accompanying public power energy storage project case studies provide insights into various energy storage projects implemented by member utilities. They include details on why the utilities selected energy storage and the expected and actual benefits of their projects. Objectives included addressing peak load management, backup power, grid stability, frequency regulation, renewable integration, cost savings, emission reduction, and resource optimization. These projects (summarized in the table below) demonstrate the increasing importance of energy storage in addressing the challenges of transitioning to a more sustainable and reliable energy system.

Organization	Project	Capacity	Focus	Objectives
Braintree Electric Light Department, Massachusetts	Battery Energy Storage for Transmission Cost Savings	2 MW (2hr) lithium-ion batteries	Providing transmission system benefits	Peak load management, Cost savings, Renewable integration, Reliability
Lansing Board of Water and Light, Michigan	Energy Storage Options for Meeting Capacity Obligations	To be determined	Simulation and modeling to support storage investments	Peak load management, Reliability, Renewable integration
Manitowoc Public Utilities, Wisconsin	Battery Storage Pilot Projects for Exploring System Dynamics	2x 20 kWh lithium-ion batteries	Deploying pilot-scale test systems	Peak load management, Reliability
New York Power Authority	North Country Energy Storage Demonstration Project	20 MW lithium-ion batteries	Maximizing the use of carbon-free generation	Cost savings, Renewable integration, Reliability
Wakefield Municipal Gas & Light, Massachusetts	Battery Energy Storage and Microgrid Technologies Improve Resilience and Reliability	5 MW (3hr) lithium-ion batteries	Exploring different options for storage	Peak load management, Cost savings, Renewable integration, Reliability

Objectives

Cost savings

Peak load management

Reliability

Renewable integration

Braintree Electric Light Department implemented a successful energy storage project which aimed to address peak load management, renewable integration, cost savings, emission reduction, and resource optimization. The project demonstrated the benefits of energy storage in reducing peak demand, integrating renewables, and optimizing energy resources, leading to enhanced grid stability, improved system efficiency, and sustainability.

Lansing Board of Water and Light is utilizing simulation tools to analyze and prioritize multiple competing offers for energy storage projects. These projects aim to address challenges related to aging infrastructure, peak demand management, and renewable integration to improve reliability, reduce peak demand, and enhance grid stability.

Manitowoc Public Utilities conducted a pilot project involving residential-scale battery energy storage systems (BESS). The project aimed to understand the impacts of storage on the distribution system, investigate various use cases, and assess the potential benefits of peak shaving, emergency operations, microgrids, black start, and frequency regulation. The utility's monitoring and analysis provided valuable insights into the performance of BESS, potential impacts on the grid, and the need for structural or operational changes to ensure efficient and reliable operations in the future.

New York Power Authority's North Country Energy Storage Demonstration Project aimed to capture renewable energy from wind farms and hydropower facilities using lithium-ion batteries. By addressing transmission congestion challenges, the project enabled the conveyance of low-cost, low-emission energy to high-demand areas. The project showcased the economic and environmental benefits of energy storage, maximized revenue from renewable generation assets, and facilitated optimal use of available renewable energy resources.

Wakefield Municipal Gas & Light implemented two energy storage projects, including a battery storage system and an "Energy Park" utilizing microgrid technologies. The battery storage system successfully managed peak loads, reduced emissions, and provided financial benefits for electricity customers. The Energy Park, still under design, aims to maximize the use of renewable energy, decrease dependency on non-electric sources, and enhance reliability for two schools. Both projects showcased the benefits of energy storage in cost management, emission reduction, peak shaving, and improving grid resilience.

LESSONS FROM PUBLIC POWER ENERGY STORAGE PROJECTS

Several common themes emerged from the public power utilities' experience with their energy storage projects. A few of the utilities also shared some unique recommendations and experiences that were a function of their specific regulatory and rate environment or their unique operational conditions.

Common Opportunities and Challenges

Several major themes were pervasive throughout the case studies, including peak load management as a significant project objective, regulatory and safety concerns and challenges, and the importance of in-house and consulting expertise for project implementation and system operation.

Using energy storage to flatten peak rates. Several public power utilities implemented their energy storage solution to provide energy during peak demand times and reduce the effects of peak pricing. This produced a positive effect on both the utility and its customers in mitigating rate increases during peak times. In one use case, the public power utility found that the use of energy storage negated the need for two gas peaking plants originally installed to deal with peak demand. Another public power utility is taking this a step further and investigating the use of energy storage to mitigate shorter period price spikes (sub-hourly dispatch), with modeling suggesting that it will save more money compared to discharge over longer periods of time (four hours of dispatch).

Regulatory and safety considerations. While all public power utilities mentioned they had support from their local and state governments, many reported issues surrounding the permitting process, as installation of the energy storage solutions often involved new elements not previously encountered in earlier public power utility projects. In addition to the standard permitting and environmental concerns surrounding any large project, energy storage solutions often include an increased focus on the risks and mitigation of fire due to the components involved. These issues required more coordination between local utilities and emergency response personnel, and, in some cases, imposed delays on the process. Some public power utilities encountered issues with insurance companies due to the new nature of energy storage projects. A common element of these issues included the importance of providing education to all parties regarding the technologies being deployed.

Importance of In-House and Consulting Expertise. Several of the public power utilities explicitly mentioned the importance of having in-house and other available expertise for dealing with issues during the planning and installation process for their energy storage implementations. These included not only having staff members familiar with renewable and energy storage systems, but also having personnel familiar with the intricacies of fire suppression and the local fire codes, and more nuanced items, such as having personnel familiar with software tools for modeling power usage.

Additional Considerations

Many of the case studies also reference common concepts. These include common benefits, technology considerations, environmental impact considerations, policies and regulations, funding, and support.

Objectives and Benefits: Common objectives cited by the projects include peak load management, grid resilience, cost reduction, carbon emissions reduction, and integration of renewable energy resources. Many case studies also include benefits such as improved grid performance, reduced congestion, increased reliability, and financial savings.

Technological Considerations: All the projects are lithium-ion battery energy storage systems (BESS). The utilities considered (and may also pursue) other storage technologies like flow batteries and thermal storage. They also highlight the importance of considering safety protocols, supply chain challenges, technical expertise, and integration with existing infrastructure.

Environmental Impact and Sustainability: Several projects emphasize the environmental benefits of energy storage projects, including the reduction of carbon emissions, promotion of renewable energy integration, and support for sustainability goals.

Policy and Regulatory Context: Most of the utilities mention the role of government policies and regulations in supporting and influencing the implementation of energy storage projects. They also highlight the need for collaboration and coordination between utilities, organizations, and regulatory bodies.

Funding and Support: The documents recognize the importance of financial support, grants, and partnerships from organizations like APPA and the U.S. Department of Energy (DOE) to facilitate the implementation and success of energy storage projects.

Notable Project Differences

Despite many similarities between experiences, not all public power utilities sought the same objectives nor made the same decisions about factors such as scale or system ownership and operation.

Energy storage solution ownership and operation: Ownership or PPA? Some utilities noted the value of direct ownership and control of their energy storage solution, while others planned to purchase stored energy via a power purchase agreement (PPA) or similar mechanism, placing ownership and control in the hands of a third party. Many participating utilities noted the careful consideration given to this decision, including analyzing the goals and costs of the energy storage project and how it would best fit within operational and long-term plans.

One size doesn't fit all. Project storage sizes varied across the case studies. One case study addresses a utility-scale energy storage facility with a capacity of 400 MWh, while another focuses on residential-scale BESS installations that are approximately 20 kWh. Size decisions were based on factors such as the utility's interest in exploration via a pilot project vs. a recognition that large-scale implementation would address pressing environmental mandates or provide hard-to-ignore economic benefits.

NEXT STEPS FOR PUBLIC POWER UTILITIES CONSIDERING ENERGY STORAGE

Collectively, the energy storage project experiences of the public power utilities highlighted in the case studies lend themselves to several steps for public power utilities to consider when implementing their own energy storage projects:

1. Assess current energy storage maturity level: APPA developed a tool to allow public power utilities to assess their preparedness for effectively planning, deploying, operating, and maintaining energy storage assets. The Public Power Energy Storage Maturity Model is designed to serve as a starting point for public power utilities considering energy storage projects.[3]
2. Conduct a feasibility study: Begin by assessing the specific needs, goals, and constraints of the utility, such as peak load management, renewable integration, grid stability, or cost reduction. Conduct a thorough feasibility study to evaluate the technical, economic, and regulatory aspects of energy storage deployment in the given context.
3. Define project objectives: Clearly define the objectives of the energy storage project, including the desired benefits, such as peak shaving, grid resilience, emission reduction, or cost savings. Align these objectives with the utility's overall strategic goals and ensure they are in line with regulatory requirements and environmental targets.
4. Identify suitable technologies: Explore different energy storage technologies (e.g., lithium-ion batteries, flow batteries, or thermal storage) and select the most suitable technology based on the specific project requirements, including factors such as capacity, duration, scalability, efficiency, and lifespan. Consider partnering with experienced vendors or consultants to evaluate and select the right technology for the project.
5. Assess financing options: Evaluate various financing options, including grants, incentives, public-private partnerships, or third-party financing models. Seek opportunities for collaboration with federal agencies, industry associations, and research organizations to access funding or expertise in energy storage implementation.
6. Engage stakeholders and build partnerships: Involve key stakeholders, such as local communities, customers, regulatory agencies, and technology providers, in the planning and implementation process. Collaborate with industry partners, research institutions, and peer utilities to share knowledge, best practices, and lessons from similar projects.
7. Develop a comprehensive project plan: Create a detailed project plan that includes design, procurement, construction, integration with existing infrastructure, testing, and commissioning. Ensure compliance with relevant regulations, safety standards, and environmental requirements throughout the project lifecycle.
8. Monitor and evaluate performance: Implement a robust monitoring and evaluation system to assess the performance, effectiveness, and impact of the energy storage project. Continuously analyze data and gather insights to optimize the system's operation, improve grid management, and maximize the benefits derived from energy storage.
9. Promote public awareness and education: Engage in public outreach and education initiatives to raise awareness about the benefits of energy storage, promote energy efficiency, and encourage participation in demand response programs. Provide information and resources to customers and the community to enhance understanding and support for energy storage projects.

3 If you are interested in using the Public Power Energy Storage Maturity Model, send an email to EnergyTransition@PublicPower.org

10. Continuously innovate and adapt: Stay informed about the latest advancements in energy storage technologies, regulatory developments, and industry trends. Foster a culture of innovation and flexibility to adapt to evolving energy landscapes and seize new opportunities that arise in the energy storage sector.

By considering these steps, public power utilities can lay a strong foundation for successful implementation of their energy storage projects, enabling them to enhance grid reliability, integrate renewable energy sources, reduce emissions, and optimize their operations in a rapidly evolving energy landscape.

BRAINTREE ELECTRIC LIGHT DEPARTMENT: BATTERY ENERGY STORAGE FOR TRANSMISSION COST SAVINGS

Project Overview

Braintree Electric Light Department (BELD) implemented a battery energy storage system leveraging $700,000 in funding from the Massachusetts Department of Energy Advancing Commonwealth Energy Storage (ACES) grant, awarded in 2017. The total costs were $2.7 million to complete the implementation of the 2 MW, 4 MWh battery system. The BESS went online in June 2018 and has been used for peak shaving and reduction of transmission obligations for the past five years.

Key partners in the success of this project included the project engineers from Borrego Solar Systems, Inc., who have served in construction management and preventative maintenance roles since the initial development of BELD, and IHI Energy Solutions, Inc., who served as a system integrator.

Since the implementation of the system, issues have arisen regarding the inverter and system controls. This has resulted in reduced availability of the battery capacity. The Samsung-provided batteries are currently operating at 94% of their rated capacity as the project team continues to work through challenges. Despite the reduced capacity, the system has been consistent in reducing transmission system peak loads, and in reducing related transmission costs.

Objectives of the Energy Storage Project

This project seeks to make a financial impact on the rising prices of transmission in BELD's service territory. The project team identified an opportunity to save approximately $20,000 per month in transmission costs by deploying energy storage to reduce transmission system peak demand.

In addition to the goal of reducing transmission costs, this project aims to support the relationship between BELD and the broader community by emphasizing the utility's commitment to environmental sustainability.

Benefits Derived from the System Implemented

The installed BESS has been effective in reducing transmission system costs for BELD. Dispatch of the storage system is controlled by Energy New England (ENE), a wholesale risk management and energy trading organization serving the needs of municipal utilities in the northeastern United States. ENE dispatches the BELD BESS about 3 – 7 times per month for transmission peak management purposes. Since commercial operation of the BESS began, the system has seen 300 operations, equating to over 700 hours of dispatch time. In terms of effectiveness, the BESS has caught over 90% of the intended peaks. Operational experience has proven that summer and winter peaks are easier to predict, while shoulder months tend to be more difficult.

Driving Factors for Project Success

BELD has a history of making strategic investments in the sustainability and reliability of its system. Prior to the start of the BESS project, BELD had already invested in four 2 MW gas engines and numerous solar installations that include rooftop landfill and carport arrays. BELD's technical personnel, including engineers and electricians, had extensive experience in implementing, operating, and maintaining diverse electrical equipment. BELD was able to perform much of the needed installation and commissioning for the BESS in-house, reducing the overall project implementation cost.

Additionally, no significant operational changes were needed to integrate the battery system. Impact studies were performed prior to the system implementation. Minor feeder adjustments were made to enable monitoring for reverse power flow. No back-feeding has been observed to date.

The ACES grant served as a significant driver for implementation of the project. The availability of grant funding positively impacted the projected payback for the system. From an economic perspective, the project provided an attractive return, making it a smart investment decision, regardless of the environmental benefits.

Finally, the coordination between various project partners, including BELD, Borrego, IHI, and ENE has made implementation and use of the system effective and straightforward.

Lessons Learned and Potential Improvements

Concerns related to National Electric Safety Code compliance and environmental impact mitigation arose when attempting to incorporate the BESS into an existing 115 kV switch yard. The footprint of the switch yard was expanded, requiring an environmental review, and mitigation to potential wetland impacts. The layout of the switch yard equipment was amended, including changes to equipment spacing. The primary three-phase system was expanded, including a new transformer for interconnecting the batteries. In addition, a new ground grid layout was implemented. The fence line extensions and environmental approvals required external review and town approval. Future projects will benefit from explicit and upfront consideration of complexities that arise from the engineering and permitting approval processes.

Coordination with the local fire department and inspection services represented additional roadblocks in system implementation, as these organizations did not have familiarity with fire suppression systems for battery storage technologies. To address safety concerns, coordination, shipping, and installation of the batteries required unique equipment configurations and installation procedures to ensure temperature controls at all times. Continued operation and maintenance of the system requires maintaining proper PPE and safety procedures for working with stored energy. Appropriate training regarding safety and compliance were necessary aspects of project success.

BELD installed a battery system with the capacity to discharge at full rated power for two hours. In the future, BELD will consider a three-hour battery when designing systems for peak shaving operations. It has been found that the two-hour battery presents difficulties when attempting to capture peaks. As more distributed energy resources are integrated into a system, periods of peak demand tend to shift in less predictable ways. At times, BELD has discharged its BESS at less than peak capacity (1.5 of 2.0 MWs) to extend the discharge/runtime and ensure the entire peak is captured. Based on its operational experience to date, BELD has concluded that the benefits of owning a BESS do not outweigh the disadvantages. In the future, BELD is likely to utilize a third-party arrangement for accessing energy storage assets, instead of opting for direct ownership. A third-party arrangement frees up crucial staff resources within BELD, allowing them to focus on other important aspects of utility operations.

Opportunities for APPA and DOE Support

Looking forward, BELD has a goal to generate 80% of its wholesale power from green energy resources by 2025. BELD plans to implement a variety of new technologies and programs for its customers, including a smart thermostat program, additional solar arrays, electric vehicle charging infrastructure, and heat pumps. Additionally, BELD plans to upgrade its BESS to add 5 MW of additional capacity with 3 hours of dispatch capability. BELD will seek a shared savings arrangement for the upgraded system.

APPA and DOE can continue to support energy storage developments in the public power community through advocacy and policy development. In particular, supply chain issues related to distribution transformers have resulted in increased cost and lead times for electric power utilities. Energy conservation standards for distribution transformers proposed by DOE may exacerbate market conditions and economic impacts for utilities. It is suggested that APPA continue to work with DOE to ensure that the needs of public power utilities are represented.

CASE STUDY

LANSING BOARD OF WATER AND LIGHT: ENERGY STORAGE OPTIONS FOR MEETING CAPACITY OBLIGATIONS

Project Overview

In anticipation of retiring coal generation facilities and a quickly expanding industrial base, the Lansing Board of Water & Light (BWL) released an all-source RFP for capacity and energy in 2023. In response to the RFP, a variety of energy storage projects were proposed. These proposals have brought to light the need for expanded expertise and education pertaining to all aspects of storage technologies, including prediction and modeling, planning, integration, and operations. Energy storage projects have been proposed to address resource adequacy, energy arbitrage, carbon emissions reductions and provision of ancillary services.

As the transmission and distribution grid will require handling distributed energy resources in the future, energy storage may play a key role in providing flexibility, alleviating peak load conditions, and managing congestion.

BWL commissioned a cross-functional team to evaluate the proposals received. This team is comprised of representatives from the utility's transmission and distribution operations divisions to offer perspective on potential use cases for energy storage, and optimal placement of storage assets on the grid. If deployed optimally, energy storage can be used to address local distribution challenges, to provide ancillary services, and to provide capacity to meet peak demand.

Objectives of the Energy Storage Project

This project seeks to address resource adequacy concerns that arise from two primary considerations: retiring generation and unprecedented load growth. BWL has retired multiple coal-fired power plants, which now require replacement capacity. In addition, load dynamics have recently changed in BWL's service territory. Electricity demand for BWL went from flat-to-declining before the COVID-19 pandemic, to rapid growth in recent years. The recent introduction of new industrial facilities in Michigan will expand BWL's demand by 33% in 2025. The extreme projected growth has happened so quickly that it was not captured in BWL's 2020 integrated resource plan (IRP). Based on the urgent need, the analysis timeline for responses to the all-source RFP was compressed into a four-month period.

All of the energy storage responses to the RFP received represented viable technology options. However, many proposed projects were ruled out due to their financial expense or issues regarding integration with the local distribution network. BWL's transmission and distribution grid was initially constructed to provide power to customers all from one centralized coal-fired power plant which has since been retired.

Anticipated System Benefits

The primary benefit BWL seeks in deploying energy storage is to fulfill its resource adequacy requirements, accrediting its energy storage assets within the regional energy market governed by the Midcontinent Independent System Operator.

BWL also believes it will be able to deploy its energy storage assets for energy arbitrage. Modeling and analysis have suggested that using batteries to mitigate five-minute price spikes will provide greater financial benefit compared to discharging the batteries over a four-hour period to capture longer peak demand intervals.

Deploying an energy storage solution will aid BWL in achieving carbon neutrality, as energy storage can be utilized as a zero-emissions discharge resource. Compared to other dispatchable resources, carbon intensity will be measurably lower when using energy storage.

Resource adequacy represents BWL's primary incentive for deploying storage technologies. BWL intends to utilize any developed storage system for all possible use cases and market applications. On any given day, BWL will deploy its storage assets for resource adequacy purposes first. Absent this particular need, economics will determine what other use cases are captured on a daily basis.

Driving Factors for Project Success

The factors contributing to the success of BWL's effort to understand and utilize energy storage include an effective use of modeling and simulation tools, a supportive state government, the availability of grant funding programs, and the existence of additional financing options for storage projects.

BWL has been utilizing a software package named PowerSIMM by the company Ascend Analytics as a tool for evaluating the financial and technical viability of deploying storage in different scenarios. These modeling efforts have been useful in supporting BWL's integrated resource planning and production cost modeling efforts. The software allows Lansing to investigate value-based battery dispatch opportunities through stochastic analysis, which evaluates the financial risk involved with new assets. BWL is utilizing the PowerSIMM software and consulting services from Ascend Analytics to administer, evaluate and model each scenario represented by a proposal received in response to its all-source RFP. This modeling effort allows BWL to understand how the storage system will interact with its transmission constraints, loads, energy needs, capacity requirements and ancillary services markets.

Second, the financing considerations helped drive this project forward for success. Based on relevant economic models, ownership offers are attractive to have the cash flow for funding storage projects through the bond markets. Other opportunities for funding were identified through local Michigan grant proposals, low carbon grants, solar and storage grants and public, especially local, support.

Significant support exists at the state level within Michigan for energy storage initiatives. In 2020, the governor of Michigan signed an executive directive setting a statewide goal of achieving carbon neutrality across the state economy by 2050.[4] In 2022, the state's Department of Environment, Great Lakes, and Energy (EGLE) issued a report that detailed a roadmap for implementing energy storage in support of the carbon neutrality goal.[5] This pro-storage environment has provided a strong external driver for BWL to pursue its energy storage efforts.

Both national and statewide priorities concerning energy storage have resulted in funding opportunities for which BWL is actively applying. BWL submitted grant proposals to the Michigan Public Service Commission's (MPSC) low carbon infrastructure grant program and to federal programs financed through the Inflation Reduction Act (IRA). These proposals cover projects related to solar and energy storage deployments, including redevelopment of BWL's former coal-fired power plant. BWL has also been awarded the MPSC grant for the solar and storage project. BWL's proposal received significant public support. Beyond the MPSC and IRA grant programs, BWL is considering additional funding opportunities focused on waste reduction and electrification.

Apart from grant funding, BWL has several other financing models available for energy storage projects. In response to the all-source RFP, projects were proposed involving energy storage systems financed through tolling agreements (similar to solar PPAs), which are attractive in that they de-risk the investment from BWL's point of view.

Lessons Learned and Potential Improvements

BWL will soon be entering into negotiations with contractors selected through its all-source RFP. Many of the considerations BWL will take into negotiations can be useful upfront in energy storage project planning. These include insurance coverage, operational limits, battery performance over time, and asset depreciation. Insurance has the potential to complicate aspects of energy storage implementation and operation, as insurers typically prefer that energy storage assets

4 "Michigan will need 4,000 MW of energy storage by 2040: report" (2022, Utility Dive). www.UtilityDive.com/news/michigan-will-need-4000-mw-of-energy-storage-by-2040-report/620444/

5 Energy Storage Roadmap for Michigan" (2022, IEI) https://mieibc.org/wp-content/uploads/2022/03/IEI_EnergyStorageReport_FINAL.pdf

are located further from other facilities due to fire risk. Furthermore, as BWL anticipates the use of battery storage for sub-hourly dispatch, many vendors have objections. There is uncertainty about the impacts on overall battery lifetime and are pushing to constrain dispatch to a maximum of three cycles per day. Optimizing battery lifetime can be difficult for atypical use cases. For each intended use case, it is important to understand the relationship between operations, expected performance, and battery degradation over time. This is important for long term planning. Battery performance should not degrade more quickly than financial depreciation can account for. Predicting long term battery performance is important for financial modeling.

With regard to sub-hourly dispatch, BWL has found that most existing modeling tools fail at allowing dispatch granularity to be accounted for in long-term planning studies, including IRPs. Effective tools are needed to facilitate productive conversations between utilities and PUCs related to the way in which sub-hourly dispatch is valued in the context of long-term planning efforts.

Regarding workforce development, BWL sees a need for increased investment in education, and a need to get buy-in from staff concerning energy storage projects. Successful long-term management of storage assets will require the development of deeper in-house subject matter expertise. BWL has historical experience in managing thermal plants, but will need to grow its expertise in the future to account for solar, storage and other technologies. BWL has also relied heavily on consultants in the use of the software systems for performing modeling and studies. Education and training are needed for internal staff development on useful software systems.

BWL's rooftop solar program is growing, with up to 2 MW expected to be installed by 2025. As deployment of distributed energy resources continue to increase, BWL is investigating tools to aid in long-term management and dispatch. To that end, BWL has invested in a distribution management system, but it has not yet been fully deployed.

It is anticipated that costs will be incurred in upgrading the transmission and distribution system to accommodate energy storage. At a minimum, there will be interconnection costs associated with new circuit runs. Larger battery systems may require new substations to be constructed. As BWL works to decentralize its transmission system away from the retired coal plant, many new substations will be required anyway, and battery storage systems may be added synergistically. Certain areas within BWL's service territory are sparse in terms of available transmission and distribution capacity. In these areas, the addition of energy storage may require upgrades to multiple transmission lines. In situations like this, BWL will need to weigh the costs and benefits to determine if the system improvements justify the investment, or if it makes more sense to deploy the energy storage system in a different location.

Future Outlook

Within the next two years, BWL has plans to roll out a series of new customer programs, including demand response and electrification. In response to the all-source RFP, BWL is considering a number of utility-scale battery storage installations, mostly involving lithium-ion chemistries, although some alternatives have also been proposed. BWL's rooftop solar program is expanding as new customer installations are leading to increased requests for the option to include solar and storage.

BWL is considering the use of energy storage to support the deployment of DC fast chargers for electric vehicles. From a customer perspective, several locations in BWL's service territory are ideal for deploying electric vehicle service equipment (EVSE). However, those locations are suboptimal from the perspective of the distribution system. Integrating energy storage with EV chargers can allow customers to charge whenever they desire, while the storage acts as a buffer between the vehicles and the local distribution grid. The storage assets can be charged when best for the local grid, and discharged as needed to meet customer requirements.

BWL is also exploring how energy storage can be deployed in a manner that supports its distribution grid and water supply infrastructure. In particular, BWL operates water supply wells that are connected to the electric grid. It may be possible to install battery systems at critical well and pump sites, ensuring the batteries are available as needed to support the water infrastructure, while also being used more regularly for economical operations within the energy market.

Opportunities for APPA and DOE Support

BWL continues to look to APPA as an effective mechanism for sharing information and resources. In addition, BWL will continue to consider grant and funding opportunities through APPA and DOE, not just for utility-scale storage applications, but for related efforts like EVSE deployments.

BWL believes that APPA and DOE can also support energy storage efforts in the public power community by supporting education and workforce development. This includes assisting public power utilities in identifying the roles and positions needed to successfully staff energy storage programs within the utility, and in creating educational programs to allow current employees to develop new and relevant capabilities.

CASE STUDY

MANITOWOC PUBLIC UTILITIES: BATTERY STORAGE PILOT PROJECTS FOR EXPLORING SYSTEM DYNAMICS

Project Overview

Manitowoc Public Utilities (MPU) has invested in two residential scale battery energy storage systems (BESS) that are being used experimentally to better understand the potential impacts of storage on their distribution system. Each BESS is approximately 20 kWh, and each system is connected directly to the local distribution system through its own independent meter. One system is standalone, deployed at an MPU business office, while the second BESS is integrated with a 5 kW rooftop solar array and installed at a water utility building. Both systems were sized to represent the scope and scale that might be implemented by MPU residential customers.

MPU has been monitoring the performance and behavior of these systems and has used artificial intelligence algorithms to forecast system peaks and deploy these battery systems on the broader distribution network. As home battery systems and electric vehicles become more common, MPU is using these pilot projects to understand the potential impacts of storage in a future with high energy storage deployment rates in the residential sector.

Objectives of the Energy Storage Project

MPU is using its battery test systems to explore a variety of use cases for energy storage. In particular, MPU is investigating the benefits and drawbacks of using energy storage for peak shaving, emergency operations, temporary microgrid setups, black start, operating reserves, and frequency regulation.

As a part of its investigation, MPU has been measuring peak demand on its distribution system, and actively charging and discharging its battery systems in attempts to capture daily peaks. MPU employs a variety of algorithms to improve its accuracy in forecasting peaks and is using measurement approaches to validate the performance of its systems. In addition, MPU is actively developing metrics to better understand the impact of capturing or missing peak periods.

MPU's engineering department is performing analyses and system studies to determine whether the storage units are having measurable impacts on the performance of the distribution grid.

Based on the findings from these initial studies, MPU will be able to estimate impacts in future scenarios (e.g., a 10% adoption rate for residential battery systems, integrated solar and storage, or electric vehicles). These studies can better help MPU to assess structural or operational changes that may be needed to ensure efficient and reliable operations in the future.

Driving Factors for Project Success

MPU has recent experience deploying innovative technology projects. As a result, their organization benefited from supportive leadership, capable personnel, and an organizational structure and management strategy that served as key enablers for the energy storage pilot projects.

MPU is converting two of its boiler units to run on biomass. These coal-fired plants will run on paper pellets exclusively by 2026. MPU has funded this effort in part through an APPA DEED grant.[6] Implementation of this refueling effort required significant changes to MPU's organizational structure, including shifts in senior management to ensure the project was adequately resourced and managed. Dedication from organizational leadership has been a driving factor for the success of the initiative.

In addition to the battery energy storage pilot program and refueling effort, MPU has also begun pilot programs investigating smart thermostats, electric vehicles, demand response, and community solar. Most of these programs have begun within the last two years. Each program is being evaluated for its impact on the distribution system and is being assessed for economic viability.

6 Renewable Fuel Conversion Study for Coal Generation (2022, MPU). www.PublicPower.org/deed-project/renewable-fuel-conversion-study-coal-generation (DEED member access only).

In the years to come, MPU is considering the creation of a new organizational division to manage the refueling project and other pilot programs. This umbrella department would ensure that responsibility and accountability are assigned for all necessary aspects of these innovative programs, including leadership and decision making, tracking value, and performing internal reporting. Creation of this new department would require hiring, new skillsets, and cooperation across different existing departments, including operations, planning, and accounting. MPU has plans to devote time and resources to these efforts and has incorporated these programs into its annual goals as an organization, tracking tasks, and incorporating progress into performance metrics. These efforts reflect the level of importance that MPU places on innovation.

Lessons Learned and Potential Improvements

The success of MPU's innovative and customer-facing programs depends heavily on tariff and rate structures. For instance, MPU's pending community solar garden currently has a waitlist for subscribers that exceeds project capacity. Subscription tariffs will fund the cost of the solar investment, negating impact on the broader rate base. Due to the popularity of the program, MPU is already considering development of a second community solar garden. Moving forward, MPU expects to structure additional customer programs in a similar way that allows them to be self-funded.

Despite this intention, municipal utilities are rate regulated in the state of Wisconsin. The state public utility commission (PUC) has authority over rate changes, and PUC staff have historically crafted rate designs on behalf of MPU. This is shifting as MPU seeks more involvement at the policy and rate design level. Most of MPU's residential customers pay for electricity using a flat rate structure. Out of 16,000 residential meters, only a handful have opted into time-of-use rates. Nearly 80% of MPU's load is composed of commercial and industrial customers, who pay separate rates for off-peak energy use and demand charges. To date, MPU's rate structures have not provided sufficient incentive to encourage customer investments in energy storage.

The most important lesson learned by MPU in implementing its energy storage pilot projects has been the need to start early, and to begin by obtaining buy-in from organizational leadership. The need to address larger global and societal issues has provided motivation for organizational changes in support of these innovative efforts.

Future Opportunities

In moving forward, MPU will apply feasibility criteria to all technology options under consideration. MPU will integrate the results of its pilot projects into its integrated resource planning process, with a goal to develop actual utility scale storage capacity that can be bid into the regional energy market, governed by the Midcontinent Independent System Operator.

MPU anticipates that demand side management will become a significant part of its capacity supply stack. MPU is considering using demand side management to actively supply up to 15% of its capacity obligation.

As a broader array of technologies are deployed on the grid, MPU sees customer interfacing and communications as foundational aspects of its implementation strategy. MPU will need to transparently communicate the potential impacts of new technology adoption.

Opportunities for APPA and DOE Support

Funding is also essential to continue furthering the progress made from the energy storage pilot projects. MPU will look to APPA and DOE for grant opportunities, through DEED and other programs, to promote the success of demonstration and deployment initiatives.

Apart from providing funding, MPU sees value in the APPA DEED program as a mechanism for sharing information and learning from others. MPU encourages APPA to continue supporting efforts like the Energy Transition Community and Energy Storage Working Group, supporting pods of conversation within the public power community, and publishing useful studies and reports. MPU often utilizes APPA's reports on electric vehicle charging, community solar, tariff design, peak management strategies, and rate design to assess what is feasible and applicable to its own needs.

MPU is particularly interested in any ongoing work by APPA or DOE related to rate design and focusing on residential demand charges and impacts from electric vehicles. While many studies focus on the source and cause for emerging infrastructure costs, there has been less of an emphasis on finding ways to equitably allocate the costs through effective rate design.

CASE STUDY

NEW YORK POWER AUTHORITY:
NORTH COUNTRY ENERGY STORAGE DEMONSTRATION PROJECT

Wind turbines near Chateaugay, New York. Photo: Emily Russel; https://www.northcountrypublicradio.org/news/story/39258/20190805/the-road-to-renewables-new-energy-storage-facility-slated-for-chateaugay

Project Overview

A core mission of the New York Power Authority (NYPA) is to contribute to the adequacy, reliability, and economy of the supply of electric power in New York. In 2017, the New York State legislature recognized that there was a gap in energy storage capacity that could impact the state's ability to achieve its bold decarbonization goals. Acknowledging the need to address key market concerns and demonstrate the operational viability of large-scale energy storage systems, NYPA entered into its first utility scale energy storage project in 2018. NYPA planned to gain experience through the development, operation and optimization of a utility scale project through hands-on expertise in a fast-growing, rapidly changing environment. The project would also help advance the State's aggressive climate action and decarbonization goals. In 2022, Governor Kathy Hochul announced a framework for the state to reach 6 GWs of energy storage by 2030[7].

NYPA's Northern New York Energy Storage Project is a 20-megawatt per hour (MW/hr) lithium-ion battery system developed and launched in Chateaugay, New York, in Franklin County, about 40 miles northwest of Plattsburgh. Renewable resources represent 80% of the power generation in the region, which includes more than 600 MW of wind generation and more than 800 MW of hydropower generation from NYPA's St. Lawrence—Franklin D. Roosevelt Power Project. The power storage project uses lithium-ion batteries to capture 20 megawatts (MW) of energy generated by renewable resources and make it available to the grid during high-demand periods.

7 https://www.governor.ny.gov/news/governor-hochul-announces-new-framework-achieve-nation-leading-six-gigawatts-energy-storage

Energy storage systems will serve many critical roles to enable New York's clean energy future as more intermittent renewable power sources like wind and solar continue to provide a larger portion of New York's electricity. These storage systems will be used to smooth and time shift renewable generation from periods of high-generation/low-demand to periods of low-generation/high demand. Energy storage also will allow New York to better meet its peak power needs without primarily relying on generating plants that currently use fossil fuels during peak demand periods. The battery energy storage project has not yet been commissioned, but once operational, the installation will allow greater use of energy generated by renewable resources to address high demand seen in more heavily populated regions of New York State. The energy from these renewable resources is also lower-cost than other available generation, improving the economic sustainability of the state's generation profile.

Prior to starting the project there were several known challenges to the development of a utility scale energy storage system. The large number of new technologies and potential risk for safety issues created uncertainty in permitting and code requirements that had to be addressed to ensure safety as the systems were built and set for operation. Revenue reliability based on energy markets and utility tariffs did not provide the long-term performance confidence for investors to develop utility level energy storage systems. Throughout the course of the project, NYPA and its team of engineering, design and construction consultants encountered numerous unforeseen challenges, including code changes, COVID-19, supply chain delays, evolving electrical safety standards and import tariffs.

The Moses-Saunders Power Dam, seen from the Canadian side of the St. Lawrence River, which provides power to the St. Lawrence-Franklin D. Roosevelt Power Project. Photo: NYPA https://en.wikipedia.org/wiki/Moses-Saunders_Power_Dam

Objectives of the Energy Storage Project

The project was motivated by the realization that the increase in renewable power generation assets in New York created a corresponding need for increased capacity to store that energy to meet the State's decarbonization goals. This project would meet several objectives for NYPA to support the New York State goals, outlined in the Climate Leadership and Community Protection Act (CLCPA) in 2019, of increasing the renewable targets to 70% by 2030, increasing energy storage goals, and supporting an increase in renewable energy penetration. While a 20 MW energy storage project would account for a fraction of the 6 GW set forth in the CLCPA, NYPA recognized that the knowledge gained from building and operating a utility scale battery system would provide insight into the applicability of the technology in the energy market and be of great value not only to NYPA and New York State, but also to other utilities. This project was motivated in part by the State of New York's Reforming the Energy Vision (REV) initiative, introduced in February 2016,[8] which ultimately inspired the New York State Climate Leadership and Community Protection Act, which passed in July 2019[9]. When the act passed, design for the North Country Energy Storage Project was well underway. The battery installation will improve the ability for New York State to convey power from low-cost, low-emissions generation to areas of high demand, addressing both environmental and economic goals. The project will reduce curtailments of renewable energy resources, which are abundant in the North Country region.

8 https://www.ny.gov/sites/default/files/atoms/files/WhitePaperREVMarch2016.pdf

9 https://www.utilitydive.com/news/new-yorks-landmark-reforming-the-energy-vision-framework-remains-both-vita/610015/

Benefits Derived from the System Implemented

The immediate benefit of the project is to provide the capability to store undeliverable renewable energy production for customer use during peak periods and help avoid curtailment of renewable energy resources as additional renewable generation penetrates onto the grid. NYPA is able to capture the wholesale market revenue opportunities including energy pricing arbitrage and frequency regulation. In addition, by owning, operating, and maintaining the system, NYPA gains first-hand experience on the costs, benefits, and risks of developing utility level energy storage systems.

NYPA's knowledge of utility scale energy storage systems will provide an opportunity to collaborate with the New York Independent System Operator (NYISO), New York's grid operator, to validate the benefits of the battery-based energy storage system to the grid. This knowledge will be leveraged to contribute to the NYISO's adoption of market rules that facilitate the renewable integration with storage. Finally, it will serve as a valuable demonstration opportunity for NYPA and other key storage market stakeholders to increase the development of energy storage systems.

An ancillary benefit for NYPA is the understanding of the complexity of energy storage technology and the risk mitigation measures required to ensure the public health and safety of New York State residents. NYPA is part of a new Inter-Agency Fire Safety Working Group created by Governor Hochul to independently examine energy storage facility fires and safety standards. NYPA's engineers met with local fire departments for training on the new battery system and NYPA, throughout development, construction and operation, has ensured that the Northern New York project meets all fire safety and permitting requirements.

As battery technology continues to evolve and more is learned through the long-term uses of battery energy storage systems, NYPA is well positioned to participate in the development of policies and regulations to ensure public safety and the reliability of the electric grid.

Drone view of the Northern New York battery storage project, with the Willis substation adjacent to the facility

Driving Factors for Project Success

The project has been a success due to the hard work of NYPA personnel in navigating challenging, unforeseen project elements. At the onset of this project there were known risks that were identified, which included the cost uncertainties with the technology, unforeseen construction costs, energy market pricing, and regulatory and code changes. The COVID-19 public health crisis that started as construction on the project was ramping up lead to the realization of these risks with supply chain delays, price escalations, and new import tariffs, which ultimately resulted in increased project costs. To overcome these obstacles, it took a dedicated team of engineers, technical experts, contractors, supply chain management and operators.

While battery storage technology has been around for decades, significant changes in regulatory and code requirements were needed due to technology advancements. NYPA and the project team began the project by selecting a design that ensured the highest level of compliance with existing building codes. New York State accelerated the issue of a Supplement to the Uniform Fire Prevention and Building code specifically for battery storage facilities when the project was underway, adding to the complexity of permitting and bringing the project into compliance with the most recent codes. NYPA is fortunate to have agile and responsive personnel able to respond to the changes quickly and effectively. Among these, engineering personnel on staff were familiar with the code and able to ensure compliance. While these challenges are not unique to a project in New York State, the skills and experience of the project staff were instrumental to its success.

NYPA prides itself on its commitment to safety and environmental stewardship. During the project, NYPA incorporated many design features to address safety and environmental concerns associated with lithium-ion battery storage systems. Incorporating the design features contributed to schedule delays and increased costs to ensure the highest compliance with NYPA's stewardship goals.

The resourcefulness of project personnel was also tested by the onset of the COVID-19 pandemic and the associated supply chain challenges. First, the onset of the pandemic provoked a brief moratorium on project construction. Once construction resumed, limitations in the supply chain impeded acquisition of many of the necessary materials and equipment. Exacerbating issues with the supply chain were tariffs on many Chinese imports, among which were the materials necessary for the batteries (e., containers.g., NEC batteries, though produced by a Japanese company, were manufactured in China). These tariffs added additional expenses to the project, beyond its initial financial commitments.

Lessons Learned and Potential Improvements

Over the course of the project, NYPA developed internal procedures and documentation, which will be useful in streamlining the development of future energy storage projects. While some obstacles, such as the pandemic and tariffs, were not foreseen, the ability of the project personnel to navigate a complicated and evolving set of codes and regulations improved the project's prospects for success. Energy installation projects all present unique challenges in geography, demand, generation types and availability; however, some generalizations can be made from the challenges seen in this project to other potential issues that may arise in future installations.

Future Opportunities

In addition to the Northern New York Energy Storage Project, NYPA is developing a broader portfolio of energy storage systems, including a pilot project in White Plains, New York. This project seeks to address potential thermal runaway fire risks associated with lithium-ion batteries and help facilitate energy storage projects for large urban areas, which can face siting difficulties due to concerns with safety and their footprint. The White Plains project has been operational since August 2022.

In addition, a high-temperature storage-based combined heat and power (HTS-CHP) project is installed in suburban Westchester County on the State University of New York's Purchase campus and employs a storage media of crushed rock. This pilot scale installation is complete through the Con Edison interconnection and testing for the CHP portion of the system. The energy storage aspect of the installation is undergoing commissioning at present.

NYPA is exploring other storage technologies, including non-lithium-ion batteries for inner city application or longer-term storage. For example, NYPA is investigating the potential for long-duration energy storage through the application of a zinc-air flow battery with a duration of 10 hours. This battery technology, if scaled, could be designed to provide longer service during an outage and thereby improve overall grid resilience.

NYPA commissioned a Small Clean Power Plant (SCPP) Adaptation Study to analyze potential clean energy options to decarbonize its "peaker plants" in New York City. The study concluded that with the advent of more renewable energy coming into New York City and the resulting decrease in the frequency and duration of peak energy demand, four-hour energy storage could provide enough energy to replace the operations of each small clean power plant. NYPA is moving forward with further assessments of resiliency and reliability, as well as the capacity requirements to ensure sufficient power can be provided to New York City residents with the implementation of utility level energy storage systems.

All of these projects contribute to NYPA's key objectives to gain first-hand experience on the costs, benefits, and risks of developing a utility scale energy storage system and an understanding of its expanded role which will enable the development of more renewables in the state. With this knowledge, NYPA strives to be a driver in developing market rules that facilitate further development of utility scale storage systems throughout New York State and enable the integration of renewable power generation. Recently NYPA was given a new authority to develop, own, and operate renewable energy projects, either alone or in collaboration with other entities. In conjunction with NYPA's ongoing efforts in energy storage systems, this authority will provide even greater opportunity to integrate renewables into the energy market and assure the ability to achieve New York's Climate Act goals.

Opportunities for APPA and DOE Support

In pursuing these projects, NYPA made a significant capital investment to increase the infrastructure to support increased renewable energy capacity on the grid. Through the Infrastructure Investment and Jobs Act (IIJA) and the Inflation Reduction Act (IRA), NYPA plans to access new and existing federal tax opportunities to lower the costs of certain renewable energy projects that it would undertake under the enactment. In addition, NYPA is pursuing opportunities with the U.S. Department of Energy (DOE) and APPA to continue their efforts to advance renewable energy and related technologies in the areas of generation, transmission, and energy storage. As all research, development and deployment projects require financial support, and NYPA has wide-ranging demands beyond the scope of these projects, NYPA believes that APPA and DOE can aid in realizing the benefits of these projects and other installations by providing financial assistance.

Development of new technologies demands iterative exploration of challenges and identifying and closing the gaps in knowledge. In battery technology, new startups are primarily focusing on challenges in the batteries themselves. Increased focus on research and development (R&D) for BESS and control systems would improve the ability of the technology and system to marry. Improved BESS grid integration would increase return on investment and attract the interest of reliability coordinators like . Additionally, coordination of R&D efforts and knowledge sharing between operators and research organizations like the DOE National Laboratories and the Electricity Power Research Institute will continue to speed this process.

CASE STUDY

WAKEFIELD MUNICIPAL GAS & LIGHT: BATTERY ENERGY STORAGE AND MICROGRID TECHNOLOGIES IMPROVE RESILIENCE AND RELIABILITY

Project Overview

Wakefield Municipal Gas & Light (WMGLD), a public utility operating in Wakefield, Massachusetts, launched two energy storage projects, a battery storage project launched in 2018 and completed in 2019, and a multifaceted "Energy Park" currently under design, which is estimated to enter service in late 2025 to early 2026. These projects seek to manage ratepayer costs, reduce carbon emissions, and improve management of local generation resources for the suburban-Boston town and to enable peak-load management for the utility. These projects seek to improve the resilience of the grid, provide validation for the application of novel approaches and technologies, and extend educational opportunities to the broader community.

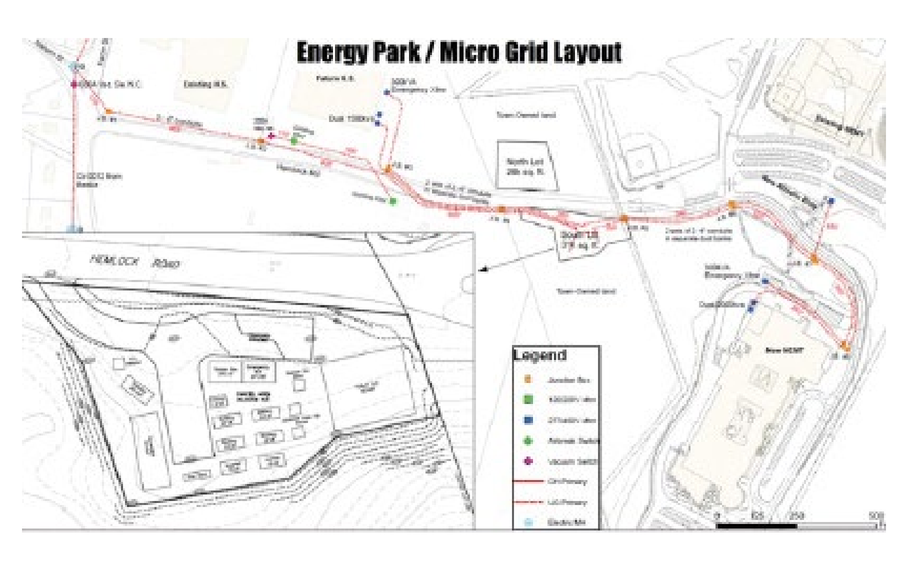
The first project uses a 3 MW / 5 MWh battery energy storage system to help manage peak loads. WMGLD selected lithium-ion batteries as a proven technology for energy storage and engaged experienced project partners in LG (formerly NEC) and Massachusetts Municipal Wholesale Electric Company. Construction of the lithium-ion system began in September 2018 and was completed January 2019, both on time and on budget. This interconnected storage system supports WMGLD's distribution system and peak-load reduction on its distribution system.

The installed NEC Battery Storage Container and Step-Up Transformers

The second project leverages microgrid technologies to develop an "Energy Park," similar in concept to a distribution substation, but with an emphasis on locally supplied renewable energy. The Energy Park will be interconnected to WMGLD's electric system, the new Northeast Metro-Tech Vocational School (NEMT), and the new Wakefield Memorial High School (WMHS). Engineering, design, and procurement are ongoing in 2023, with testing of the installed system and initial deployment expected in 2025 to 2026, along with installation of rooftop photovoltaic systems at each school. The completed Energy Park will include a 5 MW (15 MWh) battery storage unit, a 2.5 MW gas generator, and two solar arrays, 388 KWdc (at NEMT) and 425 KWdc (at WMHS). The complete installation will allow both NEMT and WMHS to maximize their use of renewable energy, decrease dependency on nonelectric carbon emitting sources, and enhance overall reliability. The battery, generator, and solar arrays will serve as the emergency power source for both schools and can serve as primary power sources during extended outages.

Objectives of the Energy Storage & Energy Park Microgrid Projects

In conventional peak-load management, a common practice is to bring smaller generators online to meet the increased need. WMGLD's approach is to manage peak loads with WMGLD owned and managed assets which provide more control over peak shaving. This is also done in conjunction with requests for residents and businesses to limit their demand on the electric grid as well. These projects seek to build multiple, complementary peak load management systems using distributed generation resources and load management. Achieving this goal is financially advantageous and environmentally beneficial. Utilizing BESS technology allows the local utility to control distributed generation and sustainably manage the balance of solar energy storage, natural gas generation, and grid connections. By improving management and



Layout of the proposed Energy Park (inset) in relation to proposed sites for NEMT (right) and Wakefield high school (left)

control of costs, these DG assets will benefit electricity customers and the environment, and reduce carbon emissions. The BESS is expected to provide reliable output for 10 to 20 years.

The Energy Park will provide energy management and environmental education opportunities for students and promote electrification in pursuit of the State of Massachusetts' goal to achieve net-zero by 2050.

Each school is required to have emergency power within 10 seconds and for life safety for emergency lighting, which initially was to be provided by two diesel generators. WMGLD proposed replacing the two diesel generators with battery storage and using a gas generator as additional emergency backup. The Energy Park will help two schools reduce their electricity bills and significantly reduce carbon emissions. Beyond the schools, the Energy Park will be used for peak–shaving and will allow the town of Wakefield to potentially use WMHS as a warming and cooling center.

Benefits Derived from the System Implemented

Since it began operation, the BESS has been used to reduce grid congestion and moderated cost rates for the residents of Wakefield. In utilizing the BESS for peak demand management, WMGLD realized immediate, significant financial benefits for its customers that will continue for more than a decade. The system has lifetime savings to date of $1.6 million in peak avoided transmission and capacity costs since the project went online in 2019.

The Energy Park is expected to provide many benefits, as outlined previously. WMGLD plans to monitor the impact of the Energy Park once it becomes operational and will compare actual versus projected results to demonstrate the impact the projects have made.

Driving Factors for Project Success

Upon initial consideration of a BESS in 2018, WMGLD found that the BESS did not provide a sufficient return on investment without outside grant funding. The use of gas peaking plants was favored for their flexibility, lower overall cost, and benefit to the rate payers. WMGLD installed two new gas generators for peak management. However, after these were installed, the utility was able to secure an $800,000 grant to support the installation of a BESS, allowing them to utilize non-carbon emitting distributed generation for peak load management. The BESS has exhibited over 95% effectiveness in reducing monthly peak demand charges since it has become operational.

Lessons Learned and Potential Improvements

Compared to a conventional electrical substation, management of a BESS requires consideration of unique risks. The chemical components of a BESS require special handling and training, and, as the technologies are quickly evolving, everyone in the industry is learning simultaneously. Anyone considering installation of a BESS should verify partner and subcontractor technical and safety experience before engaging.

The WMGLD BESS project overcame supply chain challenges that extended material and equipment lead times, particularly for international shipments. These shipping and delivery challenges complicated installation efforts. Energy storage projects benefit from risk mitigation plans that account for supply chain disruptions and encourage flexibility in project implementation.

The BESS project also faced challenges integrating site contractors and equipment providers and vetting contract language to verify performance metrics and service to protect the infrastructure owner. To avoid conflicts and eliminate uncertainty, it is recommended that contract language, and terms and conditions, be sufficiently detailed and agreed upon by all parties.

Integrating an energy storage system can require upgrades to other infrastructure and operations, which should be considered as early as possible within the scope of a project. The BESS installation required an extension of an existing fiber optic network for communication and integration with utility-operated SCADA software for monitoring. The battery system supplier provided WMGLD with a system overview and training prior to completion.

With regard to the ongoing development of the Energy Park, construction coordination and planning represent the most significant lessons learned to date. Another key area is the development of a system operating plan that will be used as a guide to ensure all stakeholders understand the operation of the microgrid. Once approved, this document will serve as a guide when programing the microgrid controller known as the Real Time Automation Controller (RTAC). The project demands coordination among multiple parties, including the contractors building the two new schools, and the contractors handling the solar installation. The solar installation will be part of the schools' construction schedules with installation planned at the end of each project. For these projects, the original design and construction was intended to be "solar ready." WMGLD moved this from solar ready to actually installing rooftop solar. With the actual installation of solar now planned there was a requirement for more detailed design and construction drawings. This has introduced complications to the design of the schools, which require an integrated design and construction approach between the local utility, solar consultant, and the school's project management team. Coordination between the various contractors is vital to ensure the schools' construction schedules areis not delayed due to the inclusion of the anticipated solar elements or energy park assets that are critical for occupancy.

Opportunities for APPA and DOE Support

For WMGLD, access to content experts represents the primary need in the rapidly evolving areas of BESS and microgrid technologies. APPA and DOE can support these efforts by contributing their knowledge of the technologies through webinars and by establishing information-sharing groups. Public power utilities would also benefit from additional opportunities for funding for proven technologies like the BESS and for innovative projects like the Energy Park. Research efforts that increase the integration of storage and renewable generation can help the public power community to improve the reliability of electricity delivery and the resilience of energy supply.

In addition, WMGLD is interested in using its energy storage systems as a learning lab for other municipal utilities. At the most basic level, WMGLD can offer tours and educational events. Other opportunities may exist for leveraging the energy storage projects for the benefit of the broader public power community. WMGLD is willing to work with APPA and DOE to further explore possibilities.

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