MASSACHUSETTS CLEAN ENERGY CENTER

Clean Energy and Resiliency (CLEAR) Program

Final Report

Natick CLEAR Program Feasibility Study

Town of Natick, MA

WILLDAN

May 31, 2022

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Acronyms and Abbreviations

ACP	Alternative Compliance Payment
ADA	Americans with Disabilities Act
BH	Broad Hill Water Storage
BOT	Build-Operate-Transfer
BRIC	Building Resilient Infrastructure and Communities
CIP	Capital Improvement Planning
CLEAR	Clean Energy and Resiliency
C&CB	Capability and Capacity Building
CWSRF	Clean Water State Revolving Fund
CPEC	Clean Peak Energy Credit
CPS	Clean Peak Standard
DER	Distributed Energy Resource
EEA	Energy and Environmental Affairs
EW	Evergreen Wells
ESA	Energy Service Agreement
ESPC	Energy Savings Performance Contract
FCM	Forward Capacity Market
GF	General Fund
ICAP	Installed Capacity Reduction
ICP	Installed Capacity Tag
IOU	Investor-Owned Utility
ITC	Investment Tax Credit
IRS	Internal Revenue Service
MassCEC	Massachusetts Clean Energy Center
MACRS	Modified Accelerated Cost Recovery System
MEMA	Massachusetts Emergency Management Agency
NG	Natural Gas
NCRS	Natick Community Resiliency System
NWS	Natick Water System
OWOW	Office of Wetlands, Oceans, and Watersheds
PACE	Property Assessed Clean Energy
PPA	Power Purchase Agreement
PPP	Public-Private Partnerships
RNS	Regional Network Services
SMART	Solar Massachusetts Renewable Target
SHMCAP	State Hazard Mitigation and Climate Adaptation Plan
SRF	State Revolving Funds
SVTP	Springvale Water Treatment Plant
TF	Town Forest Water Storage
WMS	Wilson Middle School

Executive Summary

The Massachusetts Clean Energy Center (MassCEC) is a state economic development agency dedicated to accelerating the growth of the clean energy sector across the Commonwealth to spur job creation, deliver statewide environmental benefits, and secure long-term economic growth for the people of Massachusetts. MassCEC works to increase the adoption of clean energy while driving down costs and delivering financial, environmental, and economic development benefits to energy users and utility customers across the state.

MassCEC's mission is to accelerate the clean energy and climate solution innovation critical to meeting the Commonwealth's climate goals, advancing Massachusetts' position as an international climate leader while growing the state's clean energy economy. Resilience refers to the ability of a system or its components to adapt to changing conditions and withstand and rapidly recover from disruptions. The electrical and thermal infrastructure is vulnerable to many phenomena, such as hurricanes, earthquakes, drought, wildfire, flooding, extreme temperatures, etc. Some extreme weather events have become more frequent and severe due to climate change.

MassCEC's Clean Energy and Resiliency ("CLEAR") Program[1] is focused on identifying community resiliency projects that reduce GHG emissions, integrate renewable energy sources, and provide energy resilience for critical facilities during outages. The program is a successor to the Community Microgrids Program, which funded fourteen (14) feasibility studies to identify scalable, broadly replicable microgrid business and ownership models to increase microgrid deployment and attract investment. DOE defines a microgrid as "a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity for the grid."[2]

This Massachusetts Clean Energy Center's Natick Resiliency Community Study evaluated the technical feasibility and commercial/financial opportunities for a municipal resiliency system in the Town of Natick.

The feasibility study evaluated renewable energy installations, in partnership with the public energy and natural gas utility, Eversource Energy, at the following properties ("stakeholders"):

- Wilson Middle School (WMS): WMS was built in 2003, with a gross building area of 134,000 square feet. WMS currently enrolls over 950 students. WMS has no onsite backup generation resources. 302kW roof-solar PV has been installed since 2012.
- Natick Water System (NWS): NWS is the primary water source for the Town of Natick and serves as an emergency source of regional freshwater used for drinking, domestic use, and fire protection during crisis periods. Springvale Wells/Water Treatment Plant (SVTP), Evergreen Wells (EW), and the two water storage reservoirs are Tier 1 Critical Facilities, which are facilities that are capable of causing the greatest adverse consequences, as defined by the Homeland Infrastructure Threat and Risk Analysis Center (HITRAC). SVTP has two backup generators with a capacity of 250kW and 500kW. Portable 2.2kW gasoline generators are available for EW, Town Forest Water Storage (TF), and Broad Hill Water Storage (BH). 1,500-gallon onsite backup fuel is available on the SVTP site.

[1] https://www.masscec.com/clean-energy-and-resiliency-clear
[2] https://www.energy.gov/sites/prod/files/2016/06/f32/The%20US%20Department%20of%20Energy's%20Microgrid%20Initiative.pdf

The total existing backup generation capacity is 756.6 kW. The new distributed energy resource generation proposed in this study includes solar PV plus battery at the WMS, SVTP, and BH. Only battery solutions will be at the TF and EW location because there is no available space for a solar PV installation.

The resiliency-focused technical solution is proposed to interconnect with the Eversource Energy electrical distribution system to achieve the resiliency, environmental, and economic objectives of the MassCEC CLEAR Program.

The technical solution recommends a solar photovoltaic (PV) capacity of 347 kW and battery storage capacity in the range of 175kW/700 kWh (for economic purposes) and 845kW/3,470 kWh (for maximum resiliency purposes). The resiliency-oriented solution could provide unlimited islanding capacity for BH and weeks for WMS in normal weather conditions. There are only 10 hours of islanding for SVTP, EW, and TF due to limited or unavailable solar installation space.

The current annual energy costs and CO_2 emissions for the existing loads are calculated to be $424,000 and 728 metric tons[3], respectively. This represents the baseline for the proposed technical solution. Compared with the base case, the proposed community microgrid would have a 24.9% annual energy cost saving and 12.2% annual CO_2 emissions saving. Additionally, the annual CO_2 emission reduction compared to the base case is 89 metric tons.

Given the distance between locations and reasonable funding limit projections, the recommended course of action is to pursue each of the components on each of the sites separately. With the federal and state incentives, solar installation is suggested whenever available. Assuming an attractive power purchase agreement (PPA) can be developed, the solar-battery combined system installation will offer economic advantages and environmental benefits.

An owner must have a tax liability to utilize federal/state tax incentives such as the investment tax credit (ITC) on the proposed solar and battery storage installations. The solar-battery system proposed on the three sites could be owned jointly by the stakeholders (in a special-purpose vehicle), a third-party financier, or partly owned by the utility (battery storage). Since all the stakeholders are public or nonprofit entities, a third-party special-purpose entity or Power Purchase Agreement (PPA) owner will likely need to be developed to own and manage the solar and battery system. This report will name the special-purpose entity the Natick Community Resiliency Solution (NCRS) owner. The participants will then develop and determine long-term agreements to purchase power from the microgrid owner/operator.

A financial feasibility analysis was conducted to evaluate the Town of Natick's position in a PPA deal structure by measuring capital inflows and outflows to the Town (Host) and the third-party PPA provider. The resulting capital inflows and outflows indicate strong financial positions for the PPA provider and the Town/Host when limited battery size is applied (economic scenario). The increased battery size for long-hour resiliency would cause the investment cost not to recover within the useful lifespan of the proposed DER technology.

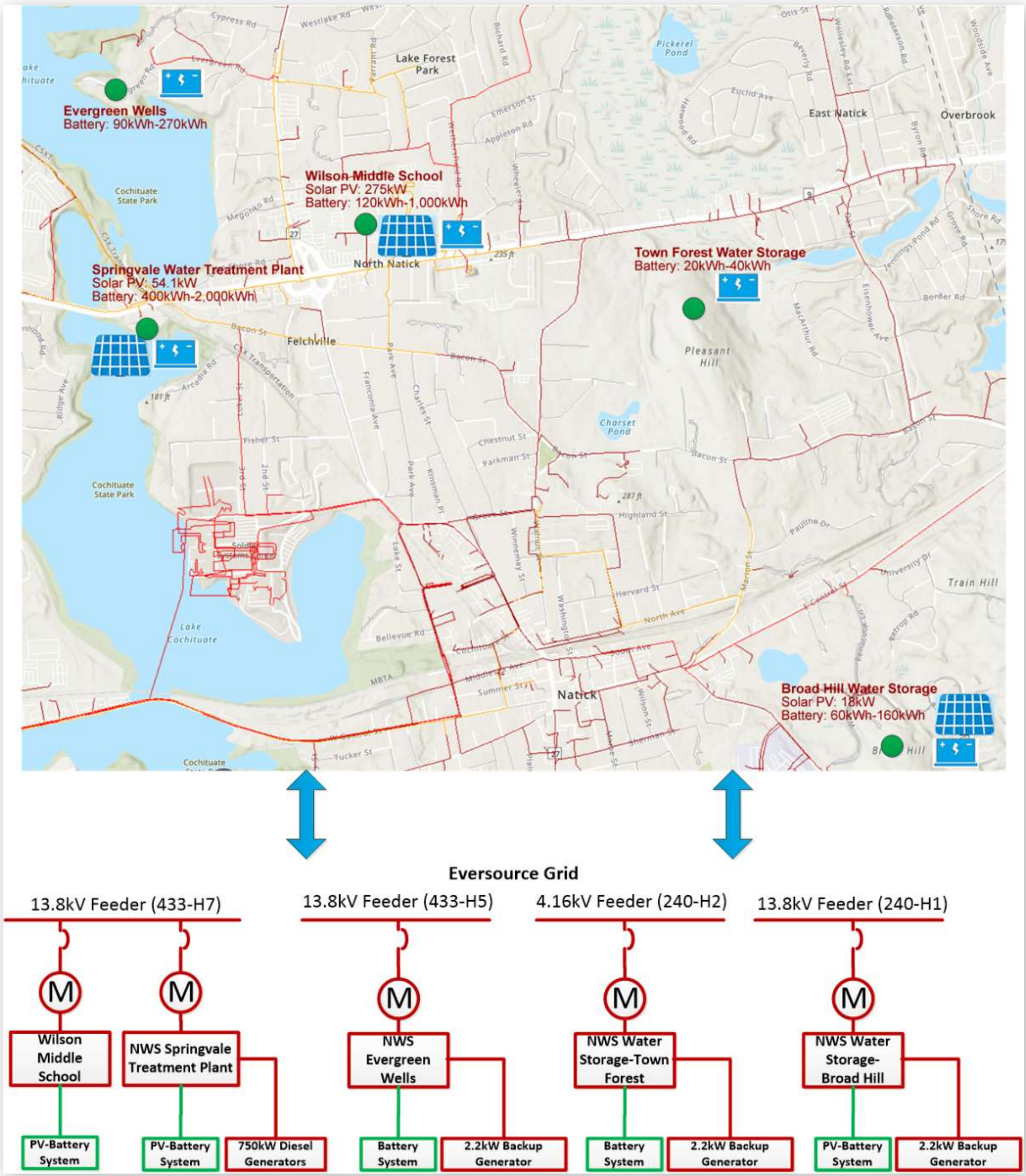
The PPA provider's internal rate of return (assuming an all-cash deal) equates to 15.9% and a net present value of $507,000, calculated using a discount rate of 8.25%. The Town's cash flow over the 20-year term

[3] Utility emission parameter of 0.4489 lbs./kWh in https://www.epa.gov/sites/default/files/2021-02/documents/egrid2019_summary_tables.pdf

is estimated at $508,0000, generating a net present value of $376,000 when discounted at a rate of 3.0% annually.[4]

Figure 1 is the final concept of the proposed technical solution, which results from the detailed assessment of the existing system and consideration of the different stakeholders' needs, requirements, goals, and operational constraints. The applied methodology and strategy will be fully elaborated in the following sections.

Figure 1. Natick Resiliency Technical Solution Concept Configuration



[4] The discount rate of 3.0 percent reflects the relatively lower cost of municipal capital from the perspective of the Town of Natick in comparison to private commercial rates.

As shown in Figure 1, all the stakeholders are spread out across the town and are fed by different feeders. The same 13.8kW feeder serves Wilson Middle School and NWS SVTP; however, they have connected customer loads not associated with the proposed configuration. This configuration increases the complexity of isolating all stakeholders and interconnecting with each other, making a connected microgrid or community microgrid difficult to implement both technically and financially.

1. Introduction

The Town of Natick (The Town) aims to achieve net-zero municipal greenhouse gas emissions by 2050. The Town recognizes the escalating threat that climate change poses to its critical facilities and the greater community. Natural hazards have already resulted in emergency events such as utility outages, highlighting local infrastructure vulnerabilities. The current energy distribution system contributes to greenhouse gas emissions and higher energy costs. In 2017, the Town hosted a Community Resilience Building Workshop through the Municipal Vulnerability Preparedness Program that identified energy resiliency improvements as a high priority. The Town has already taken steps toward addressing these climate threats by creating a Sustainability Committee and hiring a Sustainability Director, who is responsible for supporting municipal clean energy and energy efficiency projects, among other tasks. The Town also has residential clean energy and energy efficiency outreach programs, participates in an energy demand-response program, and has developed a variety of municipal solar PV projects. The Town is also beginning the process of updating its Hazard Mitigation Plan. The MassCEC CLEAR study hopes to provide another opportunity to address community energy resiliency.

This CLEAR study aims to report on the site assessment, identify resiliency needs, develop preliminary technical design and configuration, assess the commercial and financial feasibility, and perform the cost-benefit analysis for a resiliency-focused solution anchored in the Town of Natick. Willdan Energy Solutions (Willdan) is the lead technical consultant retained by MassCEC to perform the analysis and navigate the study team through the resiliency-focused solution evaluation.

The primary goals of the study are to determine how a resiliency-focused solution at this grouped location could (1) increase the

ECONOMIC BENEFITS OF RESILIENCY

Energy resiliency is achieved through the preparation, operation, and subsequent recovery from extreme weather and other prolonged adverse events that disrupt the provision of reliable power.

Municipal operations rely on a regular supply of energy and contingency measures in the event of a power failure. Causes of resiliency issues include power surges, weather, natural disasters, accidents, equipment failure, and human operational error.

Municipalities with access to reliable energy are better insulated against energy price increases or fluctuations in supply. Resiliency planning enables businesses to avoid shutdowns of important processes that impact their delivery of goods or services.

While most power outages are short-term in nature, there is a clear trend in the increasing number of large-scale natural weather events that trigger broader, longer-term disruptions.

Critical public health and safety operations such as health care, senior centers, and emergency services particularly rely on resilient energy systems to protect their communities.

The study will create the body of data on costs and system designs needed to create resilient facilities. An additional goal is to provide a replicable pathway for customers to assist utilities in outage recovery events. The study may also identify barriers, therefore helping inform future energy-related policy decisions.

fuel diversity of municipal facilities to improve the resiliency of their critical infrastructure, (2) achieve greater integration of clean energy technologies to reduce greenhouse gas emissions, and (3) cut energy costs.

The MassCEC CLEAR study builds on the resilience-focused energy planning programming started during MassCEC's Community Microgrid Feasibility Studies. Identifying technical and investment solutions will enable critical loads to "ride through" interruptions in grid service and save productivity losses.

Following the execution of the proposed work plan and scope of work, this final feasibility study report summarizes the findings from all tasks and is organized as follows:

- Section 2 presents the project initiation and site assessment (Task 1).
- Section 3 identifies each of the stakeholders' resiliency needs or requirements (Task 2).
- Section 4 presents the preliminary technical design costs and configuration (Task 3).
- Section 5 discusses the commercial and financial feasibility assessment and the cost-benefit analysis (Task 4).
- Section 6 summarizes the major findings and recommendations of the feasibility study (Task 5).

2. Project Initiation

2.1 Introduction

The proposed Natick Community Resiliency System incorporates several municipal facilities. It involves the WMS and Natick water Department with four locations at SVTP, EW, TF, and BH.

This section reviews and describes the existing site assets, including energy usage, generation resources, etc., that were applied in the proposed resiliency study. The assessment included a review of the existing documents such as the Town's Municipal Vulnerability Plan (MVP) program, the Hazard Mitigation Plan, maps, and building layouts. Generation resource load information, energy demand uses and requirements, and preferred resiliency-focused solution characteristics provided a baseline for this MassCEC CLEAR study.

2.2 Relevant Reports and Background Information

The technical team has reviewed the following reports/documents related to this resiliency study.

1. Town of Natick Community Resiliency Building Report - Summary of Findings (May 31, 2018)[5]
2. Municipal Vulnerability Preparedness (MVP) Program Yearly Progress Report (July 1, 2019 - June 30, 2020)[6]
3. Town of Natick Facility Management Study Final Report (September 2011)[7]
4. Town of Natick 2020 Annual Report - Sustainability Chapter[8]
5. Natick's Net Zero Action Plan (January 2021)[9]

[5] https://www.natickma.gov/DocumentCenter/View/6834/Natick-Community-Resilience-Building-Report
[6] https://www.natickma.gov/DocumentCenter/View/10815/Natick-2020-MVP-Progress-Report
[7] https://www.natickma.gov/DocumentCenter/View/609
[8] Town of Natick 2020 Annual Report - Sustainability Chapter
[9] https://www.natickreport.com/wp-content/uploads/2021/04/Slides_-_Natick_Net_Zero_Action_Plan_2.5.21.pdf

6. Natick Net Zero Planning Process (January 16, 2020)[10]
7. Power Purchase Agreement Multiple Schools and Municipal Facilities (June 21, 2011)[11]
8. Town of Natick Water Department Energy Efficiency Proposal (March 2013)[12]

The existing reports have noted that precipitation-based riverine flooding, extreme snow and ice events, higher temperatures, severe drought, and wind are the main hazards to this region's energy systems. Natick identified 45 priority actions through the MVP planning process, in which 25 actions were identified as a high priority, 12 as medium priority, and eight as low priority. The microgrid study is listed as the priority action within the power category[13].

The following data identified within this report will be integrated with the resiliency technical and financial solutions presented in later tasks.

2.3 Stakeholder Group Meeting

The technical team has conducted several stakeholder meetings with the local electric utility provider (Eversource Energy). The technical team met with the stakeholders two times during Task 1. The stakeholder meetings are summarized in Table 1.

Table 1. Meeting Summary

Meeting	Date	Participant	Topic
Stakeholder Meeting-01	02/23/2021	MassCEC, Town of Natick, Public Works Department (PWD), Public Safety, Willdan Group	Introduction Meeting and Kickoff
Stakeholder Meeting-02	03/11/2021	Town of Natick, Willdan Group	Introduction Meeting
Stakeholder Meeting-03	08/31/2021	MassCEC, Town of Natick, Willdan Group	Task 1 Report Feedback, Request for information
Stakeholder Meeting-04	10/04/2021	Town of Natick, Public Works Department, Willdan Group	Public Works Department operation and data review
Stakeholder Meeting-05	01/31/2022	Town of Natick, Public Works Department, Willdan Group	Public Works Department Meeting
Stakeholder Meeting-06	02/24/2022	MassCEC, Town of Natick, Public Works Department, Willdan Group	Financial feasibility study Meeting
Eversource-Willdan Meeting-01	11/18/2021	Eversource Energy, Willdan Group	Distribution System Review
Eversource-Willdan Meeting-02	02/24/2022	Eversource Energy, Willdan Group	Meeting with Utility, Historical outage data request

[10] https://www.natickma.gov/DocumentCenter/View/9108/Net-Zero-Planning-Process
[11] Solar PPA II - BH, Memorial, Wilson.pdf
[12] Natick Water-Sewer Energy Audit.docx
[13] Town of Natick Community Resiliency Building: Summary of Findings (May 31, 2018)

2.4 Critical Asset Assessment

A summary of the stakeholders' information is listed in Table 2. Each stakeholder location and its existing generation assets are shown in Figure 2. The electricity usage percentage for each of the sites is shown in Figure 3.

Table 2. Stakeholder Summary

Stakeholder		Critical Facility	Building Sq. Ft.	Annual Electricity Usage (kWh)	Backup Generation (kW)
WMS		Potential Tier 1[14]	134,000	678,027	302 kW Solar/No Backup Generation
Natick Fresh Water System	SVTP	Tier 1	N/A	1,707,272	250 kW/500 kW diesel 1500-gallon fuel storage
	EW	Tier 1	N/A	172,320	Portable generators
	TF	Tier 1	N/A	25,836	Portable generators
	BH	Tier 1	N/A	20,102	Portable generators

The summary of annual energy usage and cost is presented in Table 3. The monthly use and cost for both natural gas and electricity are presented in Section 2. WMS and SVTP have hourly granular interval electricity load data. Only monthly bill data, including use and cost, are available for EW and BH. Only annual electricity usage is available for TF.

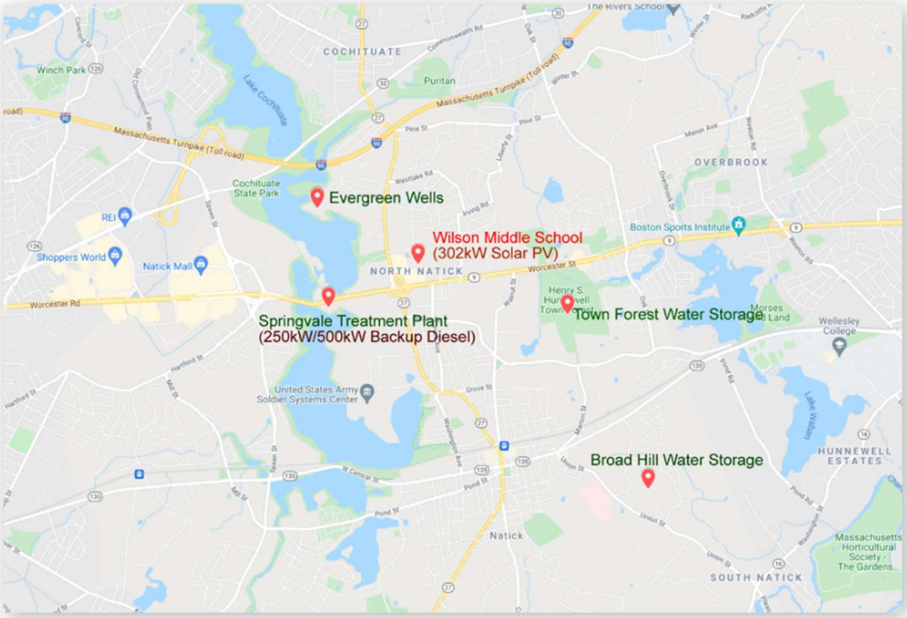
Table 3. Energy Usage and Cost

Stakeholder		Annual Gas Usage (Therms)	Annual Gas Cost ($)	Annual Electricity Usage (kWh)	Annual Electricity Cost ($)	Hourly Electricity Load Data
WMS[15]		38,975	45,119	678,027	56,610	Available
Natick Fresh Water System[16]	SVTP	12,435	12,471	1,707,272	310,034	Available
	EW	N/A	N/A	172,320	34,469	N/A
	TF	N/A	N/A	25,836	5,221	N/A
	BH	N/A	N/A	20,102	4,954	N/A

The technical team visited the five sites and toured the surrounding area at the WMS on May 24, 2021, and Natick Water System on May 25, 2021. The technical team and Natick's Director of Sustainability coordinated with Natick Public Schools, Public Safety Officer, and the Public Works Department. SVTP, which contributes 65% of the total electricity consumption, is the largest electricity user in the group.

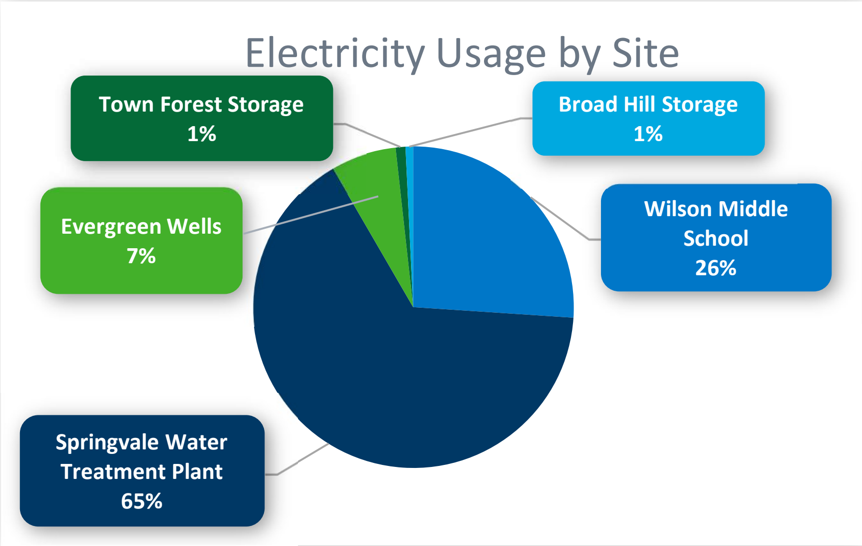
[15] Wilson MEI Data FY12-FY21.xlsx, the electricity usage data of Wilson Middle School includes the onsite roof-solar generation.
[16] Water MEI Data FY12-FY21.xlsx

Figure 2. Town of Natick Stakeholders & Existing Backup Generator Locations



Source: Town of Natick, 2021

Figure 3. Natick Stakeholders Electricity Usage Contribution Percentage



2.4.1 Wilson Middle School

As shown in Figure 4, WMS is a 134,000 sq. ft. facility built in 2003, with approximately 950 students enrolled from grades 5 to 8.

Figure 4. WMS

Figure 5 and Figure 6 show the WMS 2019 monthly electricity and gas usage with the monthly average electricity use of 26,987 kWh and electricity cost of $4,717. The 2019 use and cost also reflect the energy reduction associated with the existing 302 kW solar PV generation. As shown in Figure 5, WMS still pays the same amount of the utility distribution charge. WMS solar PV offsets almost all the onsite electricity consumption during summertime. It is anticipated that battery storage can reduce the demand charge and further reduce the cost. The monthly solar generation in the year 2019 is shown in Figure 7. The average monthly gas usage is 3,248 therms. The average electricity demand is 37 kW after the solar PV offset. The 302-kW solar PV generated 354,177 kWh electricity in the year 2019.

Figure 5. WMS Monthly Electricity Usage and Cost (Year 2019)

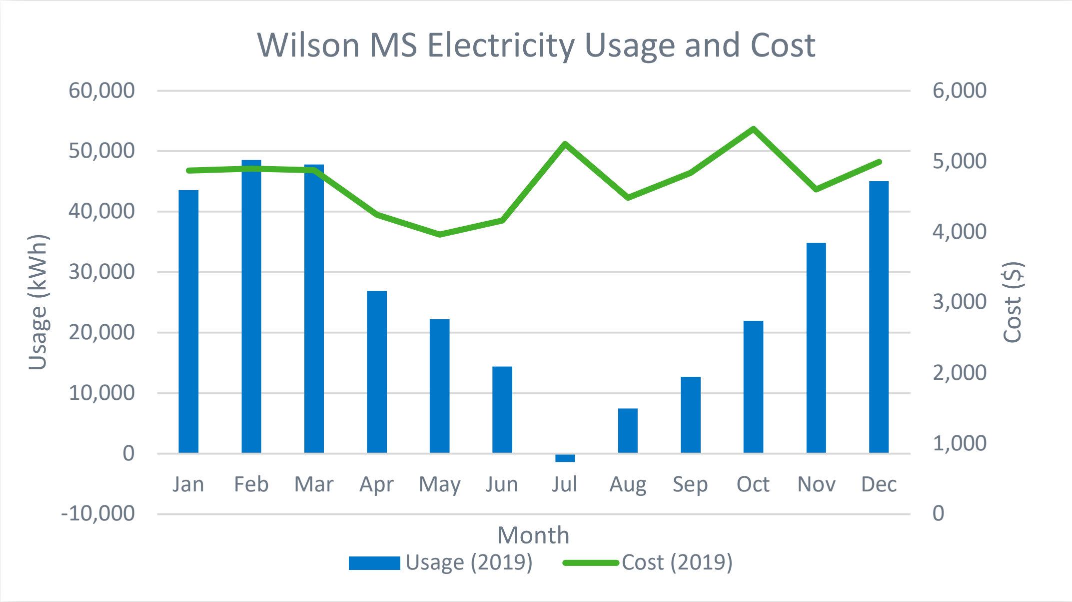


Figure 6. WMS Monthly Natural Gas Usage (Year 2019)

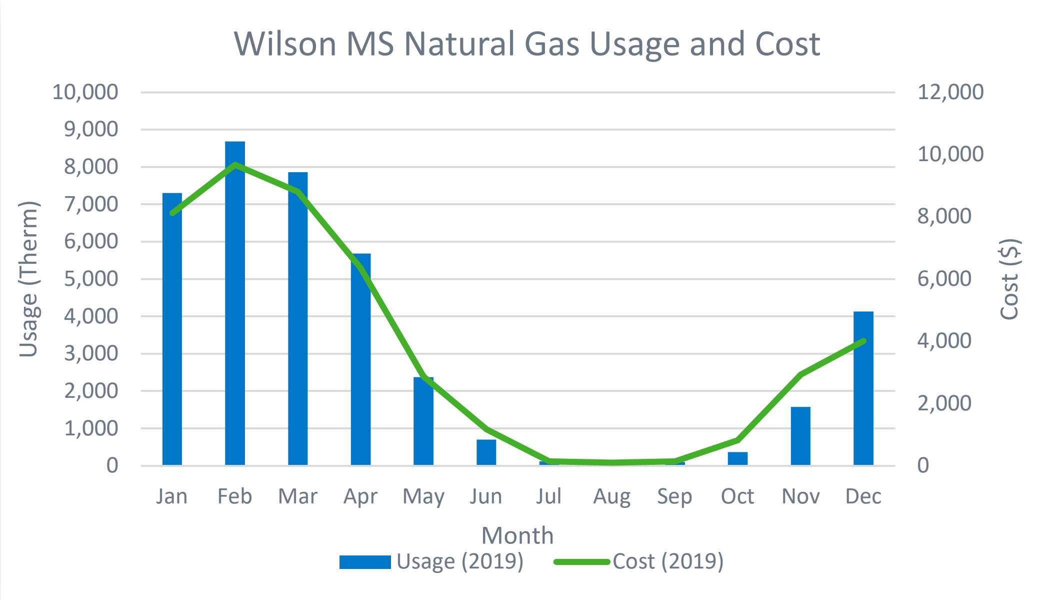
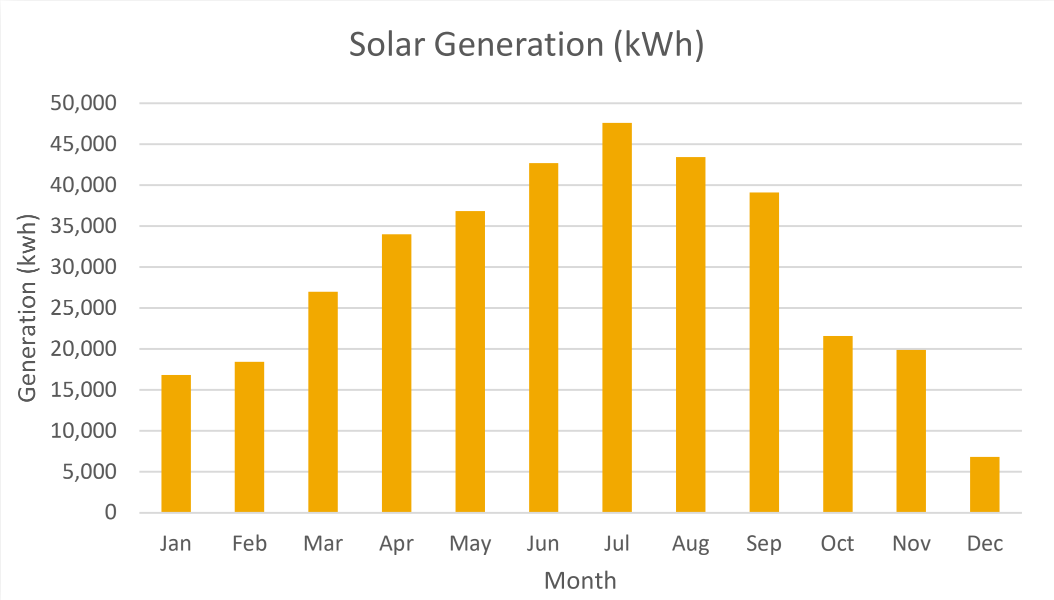


Figure 7. WMS Monthly Solar Generation (Year 2019)



2.4.2 Natick Water System

Natick's freshwater management and delivery system, shown in Figure 8, is the primary source of water for the Town and serves as an emergency source of regional freshwater used for drinking, domestic use, and fire protection during crisis periods. It includes 11 groundwater wells, 196 miles of water mains[17], and

[17] https://www.natickma.gov/DocumentCenter/View/3421/2015-CCR?bidId=

two water storage facilities. Natick's freshwater system was one of the first U.S. water treatment plants to achieve the ISO-14001 environmental management certification, with four main buildings and five of the Town's 11 wells. 70% of Natick's total water supply relies on the Springvale site. The plant pumps, treats, and distributes water from Springvale and houses the Water Division's Supervisory Control and Data Acquisition (SCADA) system to monitor and control remote sites such as the EW, BH, and TF.

Figure 8. Natick Water Treatment Plant

SVTP, EW, and the two water storage reservoirs are classified as Tier 1 Critical Facilities. Energy efficiency projects were completed through Green Communities in 2014. Evergreen's two wells are located less than one mile north of Springvale and are piped directly to the SVTP. As noted above, the EW pumps approximately 325,000,000 gallons of water each year.

Natick's water distribution system has two water storage reservoirs (i.e., Town Forest and Broad Hill) included in this study, with a combined capacity of 9,000,000 gallons. The reservoirs supplement pumped water during hours of peak usage and local emergencies. The reservoirs are located on Town property and have ample space to install ground-mounted solar arrays.

The monthly electricity usage and cost for the water treatment plant in 2019 and 2020 are shown in Figure 9. The average monthly electricity usage and cost for 2019 are 142,272 kWh and $25,836,[18] respectively. The average monthly electricity usage and cost for 2020 are 122,075 kWh and $23,456, respectively. Electricity usage in 2020 dropped by 15% compared to 2019 due to the change in building occupancy schedules during the pandemic.

The monthly natural gas usage and cost for the water treatment plant in 2019 and 2020 are shown in Figure 10. The average monthly natural gas usage and cost for this period are 1,362 therms and $1,389 in 2019, and 1,463 therms and $1,667 in 2020. The average electricity and natural gas costs are $0.187/kWh and $1.07/therm for this site. The electricity energy supply cost is $0.095/kWh.

[18] Including the distribution charges paid to Eversource and energy cost paid to supplier

Figure 9. SVTP Electricity Usage and Cost in 2019 and 2020

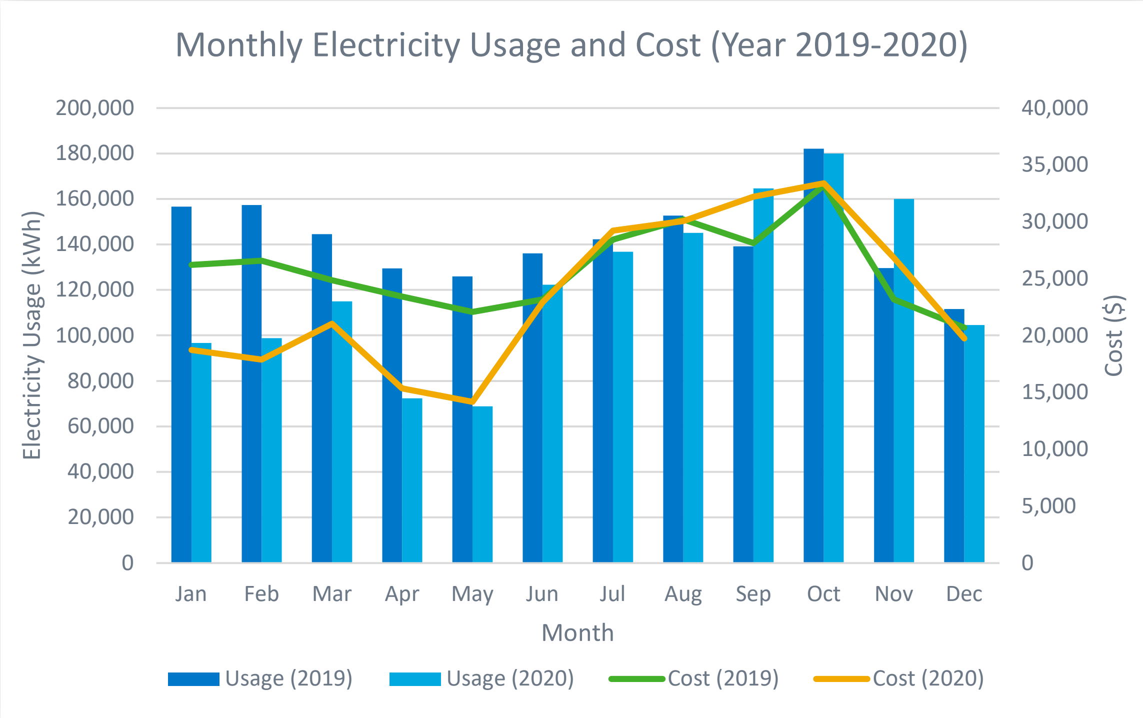
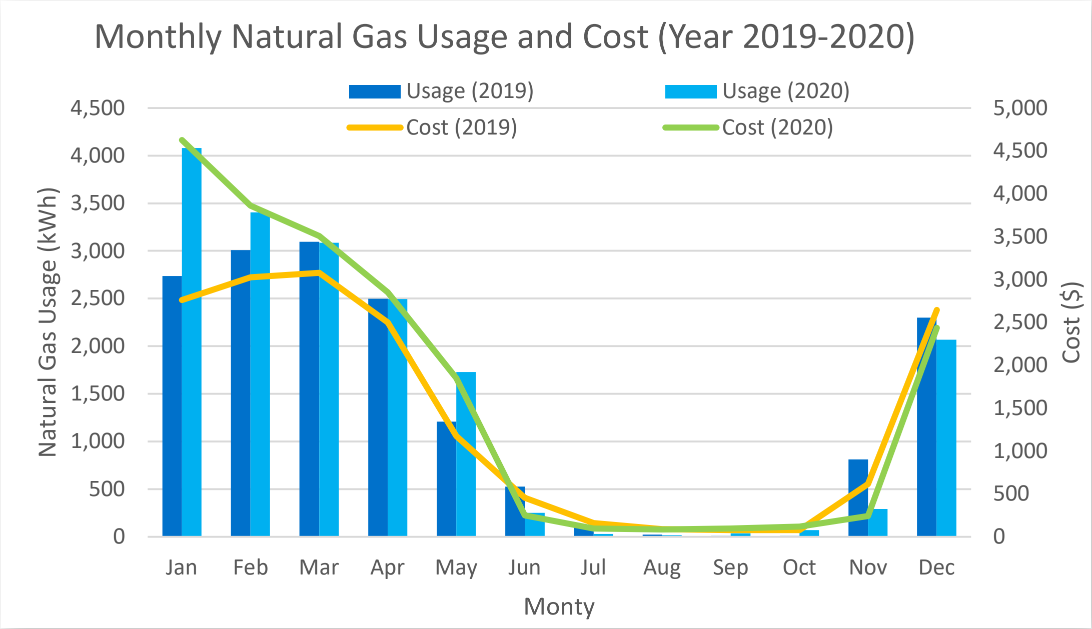


Figure 10. SVTP Natural Gas Usage and Cost in 2019 and 2020



The monthly electricity usage and cost for EW and Broad Hill water storage reservoirs are shown in Figure 11 and Figure 12, respectively. The electricity data for Town Forest Water Storage Reservoir was not available when this report was prepared. The data assumes similarity to Broad Hill in both amount and monthly pattern.

Figure 11. EW Electricity Usage and Cost in 2019 and 2020

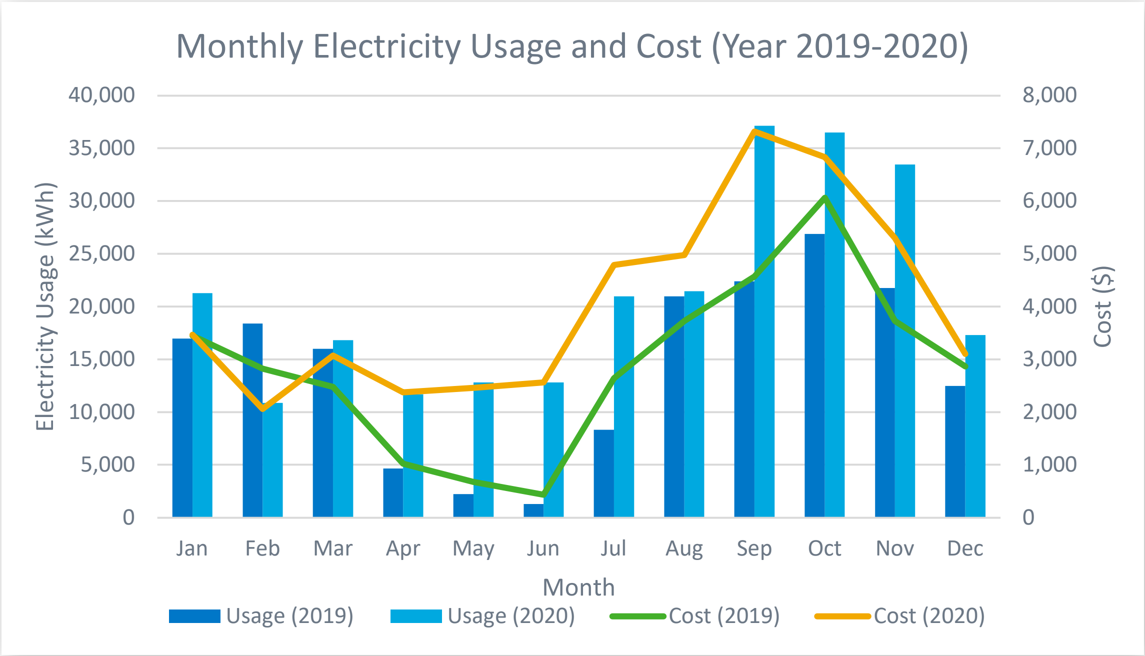
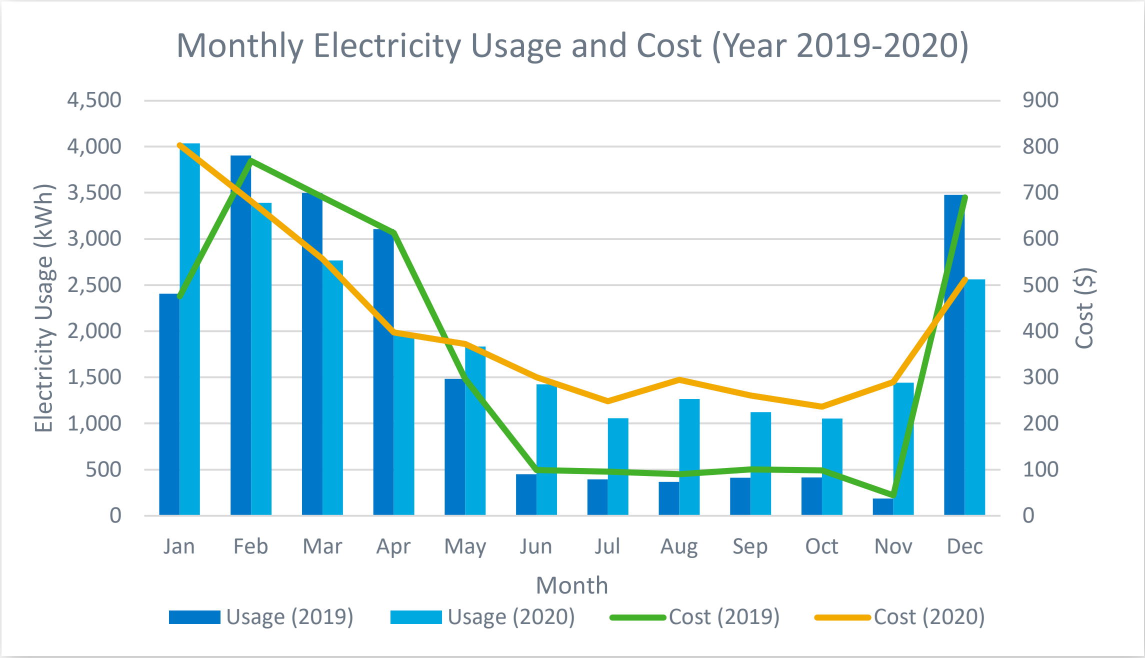


Figure 12. BH Electricity Usage and Cost in 2019 and 2020



2.5 Electrical and Thermal Infrastructure Resilience

Without the proposed solutions, the resilience of the stakeholders is tied to the utility grid or existing emergency backup generators. For those critical loads such as the SVTP (which already have an emergency backup battery/generator), the duration of running the emergency backup generator to serve the connected load would depend on the available amount of fuel in the tank or the available delivery service. Onsite fuel can generally last days up to one week.

Resilience refers to the ability of a system or its components to adapt to changing conditions and withstand and rapidly recover from disruptions, i.e., the ability to recover from a disturbance. The electrical and thermal infrastructure is vulnerable to many phenomena, such as hurricanes, earthquakes, drought, wildfire, flooding, extreme temperatures, etc. Some extreme weather events have become frequent and severe due to climate change.

Snowstorms and peak loads in the winter season could cause damage or outages to the overhead system in the Town of Natick. Also, heat waves in summer could affect distribution line conductor sags and any equipment that needs to be cooled off, such as transformers, battery storage, etc. A wind gust could cause tower/pole and conductor faults due to trees falling. It would also be necessary to upgrade designs and focus more on emergency planning and restoration. For example, in 2012 Hurricane Sandy caused a widespread blackout of the power system on the eastern seaboard and left millions of homes in the dark for periods ranging from a couple of hours to a few weeks. The extreme weather would affect both individual equipment failure and system operations. The damage from such events can impose large costs on the distribution system and severely impact the local economies.

A resiliency-focused solution would solve the constraints by providing additional capacity and resiliency to the Eversource electric system. All the feeders serving the five sites are overhead. Most of the existing distribution equipment within each stakeholder location is highly sensitive to flooding if located in the ground. The equipment that needs to be upgraded should be evaluated when design specifications are created for the infrastructure upgrades. Special attention should be paid to flood risk and reliability in severe weather. Proper controls and communication will improve resilience during weather events and in advance by providing flags and warnings for preventative maintenance and minor malfunctions before they lead to larger events that can cause grid impacts.

2.6 Project Scope Definition

As seen in Figure 2, all five sites are spread across the Town, which brings challenges to the technical study and further project implementation. We believe that a community resilience plan requires implementing a holistic and integrated community analysis, including the cyber-physical infrastructure sector's vulnerability. However, considering the statement of work approved by MassCEC and the Town of Natick MVP information, we will focus on this community's energy infrastructure resilience.

3. Identify Needs

The goals of this section (Task 2) are to report the identified needs for an energy resiliency solution utilizing a community microgrid or DER technologies. This task included reviewing relevant regulations, definitions, and assumptions. Furthermore, the data collection process and site assessment have been provided. The existing electrical distribution configuration and associated system metrics are outlined.

Finally, the resilience indexes that have been created will help define the technical solution's preferred resiliency characteristics in the following section (Task 3).

3.1 Relevant Regulations, Definitions, and Assumptions

Natick's Office of Sustainability coordinates and implements climate mitigation, climate adaptation, and waste reduction programs across the municipal, residential, and commercial sectors. Initiatives are led by Jillian Wilson Martin, the Town's sustainability director, with support from state and federal agencies, utilities, municipal departments, local boards and committees, and other community volunteers. Most of Natick's sustainability projects are funded by competitive grants and utility incentives, totaling more than $400,000 in 2020. Many projects benefit from reducing operating costs or supporting new revenue streams[19].

In 2018, during a Natick Town Meeting, the governing body for the Town of Natick adopted a non-binding resolution to achieve net zero emissions by 2050. In support of this goal, in 2020, Natick worked with the Metropolitan Area Planning Council (MAPC) and the communities of Arlington and Melrose to develop a tool any Massachusetts community could use to measure its greenhouse gas (GHG) emissions. Using the tool, Natick completed its first community-wide GHG emissions inventory and developed a five-year action plan to reduce emissions. The inventory used 2017 as a benchmark and found that Natick was responsible for emitting 326,297 metric tons of carbon dioxide equivalents. Buildings were the largest source of emissions (65%), followed by on-road transportation (35%). Natick's solid waste and wastewater facilities accounted for less than 1% of the community's total emissions.

Community microgrids that utilize both renewable energy sources and energy storage dispatch can help to reduce the need for traditionally sourced public utility-supplied electricity, creating efficiencies at many levels. As noted in our Task 1 Report, Natick's vulnerabilities to climate change are grounded in their Municipal Vulnerability Preparedness Program Report.

The Town has leveraged several energy programs to provide energy incentives and savings, including the Green Communities and MassSave® energy efficiency programs. Through these programs, the Town has completed various energy efficiency projects and explored new models for reducing energy costs. In 2020, in collaboration with these programs, the Town completed nine retro-commissioning projects at completed at WMS; these ranged from repairing leaky hot water valves to installing variable-frequency drives on supply and return fans. These projects are expected to save $36,000 in energy costs annually.

Other energy-saving programs have focused on community solar, demand response, and on-site solar photovoltaic (PV) panels. Natick recently contracted with Ameresco on the Town's first solar-plus-storage project at the new Kennedy Middle School, including 403 kW in solar rooftop and parking canopies and a 223 kW battery. These systems will save Natick Public Schools $1.7 million over 20 years. The new West Natick Fire Station has a 43kW rooftop solar array (expected savings of $140,000 over 20 years). Natick signed a large-scale community solar agreement with Clearway Solar in 2020, which will result in more than $50,000 in savings each year for 20 years beginning in 2022. It also participates in a demand response program. As part of this program, the Town reduces or shifts the electricity usage of public buildings during periods of peak grid demand. In return, the Town receives payments from the utility.

The study will need to consider the barriers to developing a community-based microgrid. Currently, behind-the-meter generation and use are allowed in the regulatory environment. Some generation export to the Eversource grid is allowed with approved precursory engineering studies. However, current

[19] 2020 Annual Report – Sustainability Chapter.pdf

regulations do not allow energy exchanges and financial transactions between different building owners in front of the meter. The distribution network of Eversource, an investor-owned utility, supplies the town's electricity. Eversource owns the franchise rights to deliver electricity and natural gas in Natick. The Commonwealth's Department of Public Utilities oversees safety concerns and rate-making policy for customer costs by Eversource. This study works toward solutions within the regulatory environment and potentially offers alternative front-of-the-meter technical solutions.

3.2 Data Collection and Site Assessment

3.2.1 Existing Distributed Energy Resources (DERs)

The two stakeholders' five locations, existing generation assets, and potential areas for new distributed energy resources (DERs) identified by the Town have been presented in Section 2. The existing DER summary information for the three stakeholders is listed in Table 4.

Table 4. Stakeholder Existing DER Summary

Stakeholder		Backup Generation (kW)	Fuel Tank Capacity (Gallon)	Generator Detail
WMS		N/A	N/A	302 kW Roof-top Solar PV
Natick Water System	SVTP	250 kW, 500 kW Diesel Generators	1500-gallon Onsite Fuel	500 kW: 1995 Vintage 250 kW: 1988 Vintage
	EW	2.2 kW Gasoline Portable Generator	1 gallon	Portable Generators are stored in remote sites for communication purposes
	TF	2.2 kW Gasoline Portable Generator	1 gallon	
	BH	2.2 kW Gasoline Portable Generator	1 gallon	
Total		757	1,503 Gallons	

3.2.2 The Building's Current Conditions and Upgrade Plans

WMS can act as a regional community resource center and is currently working to install the community's battery storage system[20]. The building already has 302 kW rooftop solar panels. A 228-kW potential solar canopy can be installed across the parking lots on campus. The Natick freshwater system provides water to residents. It serves as a backup water source for neighboring communities in an emergency. No renewable generation is currently in place.

The detailed condition of these five sites is presented in Section 2. SVTP have built new barn to house PFAs filters. WMS is scheduled to add AC to the entire building in the next 1-2 years which would add extra electric load. A new roof is also going to be needed within the next 10 years for WMS.

[20] Natick Attachments A-C and LOS.pdf, 228kW Solar Canopies and 128kW battery (early stage)

3.3 System Data Collection

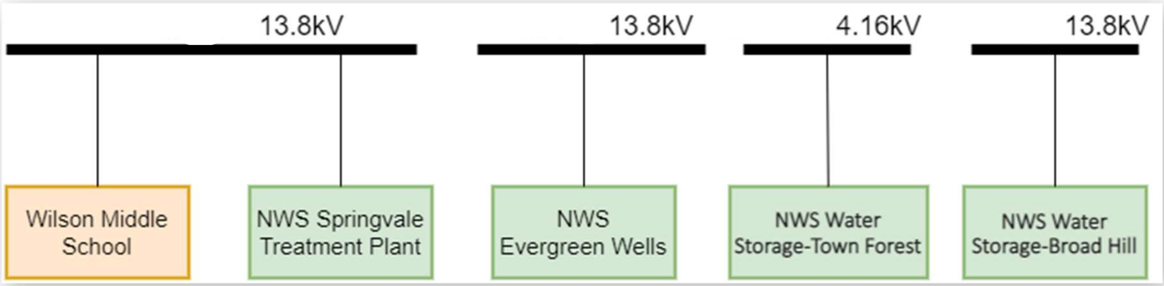
3.3.1 Distribution System (electric, water, communications)

As shown in Figure 13, the two stakeholders' five sites are served by different feeders, including three 13.8 kV feeders (433-H7, 433-H5, and 240-H1) and one 4.16 kV feeder (240-H2). Feeder 433-H7 serving WMS and SVTP has 3.31 MW of host capacity and is eligible to connect with the DER or microgrid. The other three feeders have a limited capacity of 0.05 MW for connecting with the DER or microgrid. The historical reliability index of the Eversource system for the year 2019 is CAIDI at 140 and SAIFI[21] at 0.875, respectively. Smaller CAIDI and SAIFI indexes indicate that the customers experienced fewer outages with high reliable electricity supply.

With the information provided by Eversource regarding the gas delivery system in this project area, gas pipe sizes range from 2 inches to 6 inches. The gas delivery system has sufficient capacity for the installed services. The gas system is very reliable due to the underground design. Outages are minimized from weather or extreme conditions compared to above-ground utilities.

The two stakeholders' interconnection configuration with Eversource's feeders is shown in Figure 13 for the five sites; i.e., WMS and SVTP (13.8 kV), EW (13.8 kV), TF (4.16 kV), and BH (13.8 kV)[22].

Figure 13. Distribution Feeder serving WMS and Natick Water System (NWS)



3.3.2 Needs/Requirements During an Emergency

The information below uses similar benchmarks for schools and water treatment facilities. The nearest reference is Framingham High School and Framingham's Pump Station data. The priority (or importance) of resilience is presented in Table 5.

Table 5. Priority (or importance) to the Stakeholder (1=highest priority, 5=lowest priority)

Stakeholder	Resiliency	Climate Goals	Economics	Operations	Community
WMS	4	3	1	2	5
SVTP	1	4	2	5	3

[21] Customer Average Interruption Duration Index (CAIDI) and System Average Interruption Frequency Index (SAIFI) are a reliability index commonly used by electric power utilities. CAIDI gives the average outage duration that any given customer would experience. CAIDI can also be viewed as the average restoration time. SAIFI is the average number of interruptions that a customer would experience.

[22] Eversource Hosting Capacity Map: https://www.eversource.com/content/ema-c/residential/about/doing-business-with-us/builders-contractors/interconnections/massachusetts/hosting-capacity-map

Natick Water System	EW	1	4	2	5	3
	TF	1	4	2	5	3
	BH	1	4	2	5	3

**Resiliency: Guarantees a better energy supply, in addition to the existing diesel generator*
**Climate Goals: Reduces Community GHG Emissions Portfolio*
**Economics: Rebates and incentives, unlocking energy services & benefits, minimizing the cost of the development, procurement, and operation & maintenance of energy assets*
**Operations: Maximizes the value of existing use/unused energy resources and staff*
**Community: Supports other stakeholders' critical operations & business continuity*

Wilson Middle School

A campus/community microgrid is expected to improve the power supply's reliability and stability to avoid power fluctuations and outages. The proposed solar PV combined battery storage-based microgrid system would also help the school curtail its energy bill by reducing the energy cost and demand charge.

Natick Water System

The proposed microgrid could reduce the electricity costs to run the Springvale site's main water treatment facility and support resiliency in the event of a significant disaster. The operational staff in the facility prefer simple and reliable operation, specifically during emergency conditions. They expressed a concern that the added resiliency-focused solution system would increase the system and operational complexity. The asset ownership and operation mode would need further investigation to mitigate the concerns of this facility.

A campus/community microgrid is expected to add resiliency to the facility's energy supply. The microgrid provides the benefit of keeping operations running 24/7, even during weather events/natural disasters. Another benefit would be installing new replacement capital equipment as part of this project to reduce the department's overall capital project costs. The proposed microgrid could also reduce the electric bill and thus the cost to run the pumps and support resiliency in the event of a significant disaster.

3.4 Define Resilience Index

3.4.1 Critical Loads with Available Supply

The Natick Water System is comprised of "Tier 1" facilities. The resilience expectation for each stakeholder is presented in Table 6. As a result of the resilience expectation, 70% of load of WMS and all the load of Natick Water System are critical loads.

Table 6. Resilience Expectation

Stakeholder		Disruption Delay	Maximum Operation Degradation Level	Maximum Disruption Duration Tolerance	Recovery Response Time
WMS		Hours	30%	Hours	Minutes
Natick Water System	SVTP	Seconds	0%	Minutes	Minutes to Hours

	EW	Seconds	0%	Minutes	Minutes to Hours
	TF	Seconds	0%	Minutes	Minutes to Hours
	BH	Seconds	0%	Minutes	Minutes to Hours

3.4.2 Service Delivery During an Interruption

The peak load, average load, and backup generation capacity on these sites are shown in Table 7. Only NWS has enough backup generation capacity to cover their peak load if they can be online as designed.

Table 7. Load and Backup Generation Capacity

Stakeholder		Peak Load (kW)	Averaged Load (kW)	Backup Generation (kW)	Backup Fuel
WMS		194	38	0	N/A
Natick Water System	SVTP	406	187	250 kW+500 kW	1,500 Gallons Diesel
	EW	43	20	2.2 kW Portable Generator	1 Gallon Gasoline
	TF	6	3	2.2 kW Portable Generator	1 Gallon Gasoline
	BH	5	2	2.2 kW Portable Generator	1 Gallon Gasoline

3.4.3 Recovering the Service After a Power Outage

The recovery procedures after a power outage were collected from each stakeholder or similar customers of the same business type and are discussed in this section.

Wilson Middle School

It can be a safety issue for people occupying the building to exit since no emergency generators are installed on campus. The building automation systems may need to be reset to get the heating system running again after the power outage in the winter months.

Natick Water System

The most significant factor in energy disruptions has been the momentary loss and recovery of power on sensitive electronics/system controls. These brief power changes may wreak havoc on modern systems with computer-based controls. Long-term power losses would be a concern because the department would need to relocate resources to another station, which would impact response times in the area of the outage. Typical power outages generally do not significantly impact the site's operations due to its backup generation resources. The unexpected failure of critical components in the electrical distribution system onsite has impacted the regular operation significantly.

A resiliency index weight table is defined to guide the simulation and analysis for different scenarios in later tasks, as shown in Table 8.

Table 8. Resiliency Index

Islanding Days	Load Curtailment	Resiliency Weight
7	0-30%	100%-89.41%
6	0-30%	86.76%-76.18%
5	0-30%	73.53%-62.94%
4	0-30%	49.71%-73.53%
3	0-30%	47.06%-36.47%
2	0-30%	33.82%-23.24%
1	0-30%	20.59%-10%

Resiliency weight is defined based on the following criteria:

- The maximum number of days that critical facility capacity is being responded to in the grid outage duration.
- The maximum level of a critical facility that can be served.
- Serving critical facilities with no load curtailment for seven days (as the customer's requirement) is defined as 100% resiliency.

The customer would not experience any power disruption in this best resiliency scenario, i.e., 100% resiliency weight, in which 100% of load would be continually served for up to 7 days without interruptions or curtailments. Load curtailment is the disconnection of predetermined non-critical loads, such as non-emergency lighting that can be programmed into building controllers for automated shut-off in the event of an emergency. Serving 70% of critical facilities for one day is defined as 10% resiliency weight. The resiliency weight would be 20.59% if all the loads (100% of the loads or customers) were continually served for up to one day. The higher resiliency scenario would require more backup generation capacity, resulting in a large upfront investment cost.

4. Technical Solutions

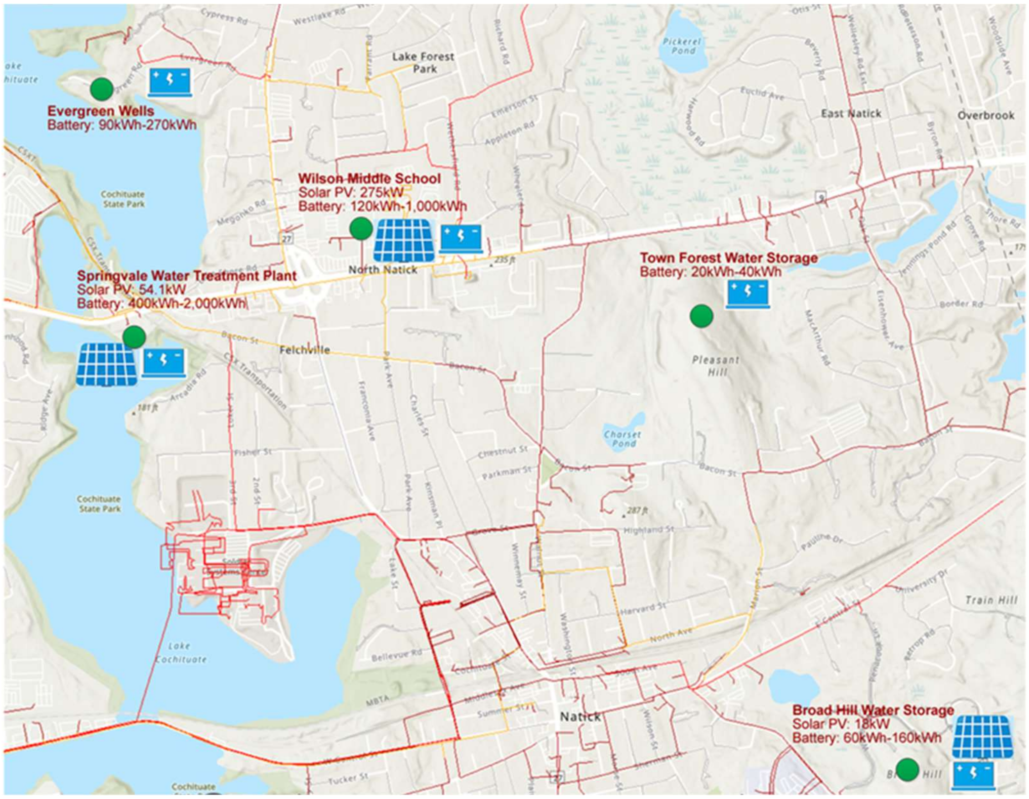
The goal of the technical analysis (Task 3) is to propose a preliminary technical design and system configuration for the proposed community microgrid anchored at WMS and Natick Water System in the Town of Natick, MA, per the findings of the site assessment and characteristics identified in Section 3 (Task 2).

A preliminary system assessment was conducted, and multiple preliminary solutions were presented to key stakeholders at the microgrid team meeting. One solution was developed further into a technical design and system configuration based on stakeholder requirements and feasibility.

4.1 Proposed Resiliency Solution Infrastructure and Operations

4.1.1 Infrastructure and Equipment Layout

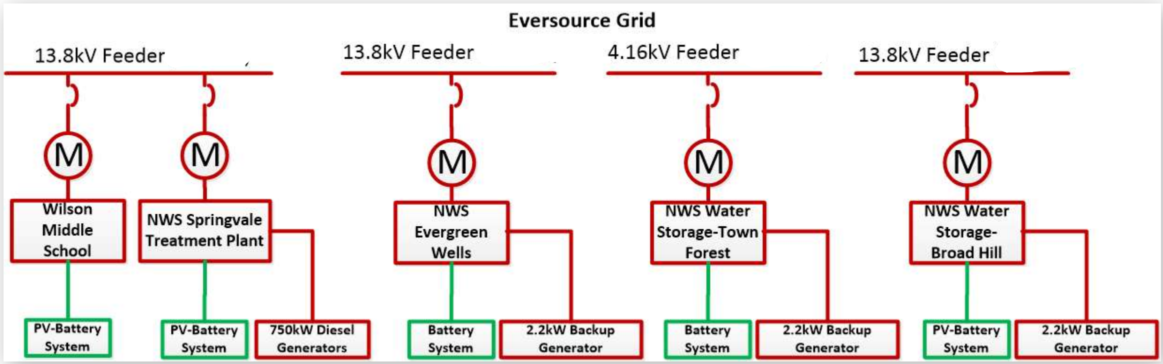
Figure 14. Natick Resiliency Solution Proposed DERs Layout



The layout of the proposed new distributed generation resources (DERs), such as solar PV and batteries, is shown in Figure 14. The backup generators shown in Table 4 are used mainly for emergency backup purposes and are not shown in this figure. Above the solar and battery icons, a red label identifies solar and battery sizing. The proposed community technical solution is a distributed building-level microgrid for WMS, SVTP, and BH. Each stakeholder location is designed as a building-level microgrid and can run independently in islanded mode. EW and TF don't have available space for solar PV and only Battery Storage Systems are suggested for providing resiliency service.

The simplified one-line diagram of the proposed technical solution is seen in Figure 15. The stakeholders are fed from different Eversource's 13.8kV or 4.16kV distribution networks. Depending on location, the behind-the-meter solar and batteries are connected to or isolated from various building loads. Each stakeholder can run independently in an islanded/grid-connected mode in this representative diagram. The stakeholders are connected to different feeders, making interconnection among the stakeholders and Utility very challenging in terms of technical implementation and practical investment cost. Therefore, under the proposed arrangement, the two stakeholders' five sites would be running and operating independently during a power outage.

Figure 15. Natick Resiliency Solution Simplified One-line Diagram



4.1.2 Existing and Planned Infrastructure

Based on the information provided by the Town and stakeholders, a total of 756.6 kW diesel/gasoline backup generator has been installed or deployed across the five sites. The existing/planned backup generation assets are summarized in Table 4.

The existing backup generators would only be running during islanded mode for extensive hours of self-supply.

The proposed solar and batteries are seen in Table 9 and consist of solar and storage systems designed to maximize solar onsite, providing backup and fast response with the batteries. Both resiliency and economic-oriented solutions are studied. In general, the resiliency-oriented solution would provide 10 hours to multiple weeks of ride-through for the critical loads of each stakeholder during a grid outage, resulting in a high investment cost and a longer payback period. In the resiliency scenario, the proposed solar-battery system could provide unlimited islanding capacity for BH and weeks for WMS in normal weather conditions, and around 10 hours for SVTP, EW, and TF due to either limited or unavailable solar space installation. The economical solution results in a smaller battery recommendation, a lower investment cost, and a shorter payback time, which would be favored by a PPA contractor, as studied in the financial assessment (Section 5).

Table 9. Proposed DER by Facility Site

Stakeholder		Solar Capacity (kW)	Energy Storage (kW/kWh) (Resiliency)	Energy Storage (kW/kWh) (Economic)
WMS		275	250/1000	30/120
Natick Water System	SVTP	54.1	500/2000	100/400
	EW	0	45/270	22.5/90
	TF	0	10/40	5/20
	BH	18	40/160	15/60

Additional infrastructure, including electrical and thermal distribution, building and grid controls, and IT/telecommunications equipment, will be added to support the installation of the generation resources above, described in their respective sections of this report.

4.1.3 Resiliency Solution Operation and Control

The proposed resiliency-focused solution could operate in grid-connected, islanded, and partly islanded modes. The advanced controller used in this solution, with the DERs proposed, will support each of the sites to transfer seamlessly between the different modes. The generation resources in different stakeholder locations would be optimally dispatched and controlled to provide economic benefits and better service to current customers toward resilient and zero-emission communities. The proposed technical solution would improve current stakeholders' and customers' power supply economics and resiliency.

Under normal conditions, the Natick Resiliency-focused solution would be operated in a grid-connected mode to maximize the economic benefits for the customers or stakeholders. The onsite controller will optimize energy purchases from the utility grid, generation, and storage from the local DERs. The controller will minimize the total energy cost while helping maintain the reliability and stability of the grid.

In emergency conditions such as utility grid outages, solar and storage will allow the sites to disconnect from the surrounding Eversource electrical distribution and transmission infrastructure and supply their power for hours to days, based on load curtailment. The solar generation and battery would optimally be dispatched to serve the critical loads within each stakeholder's location. With the proposed solution, the operation hours of the existing backup diesel generators could be significantly reduced, and reduced GHG emissions could result.

When the electric utility service is unavailable, additional loads must be curtailed during major storms or other extreme events. However, if non-critical loads are curtailed and the facilities focus on serving their critical resources such as lighting, police, fire, alarm systems, administrative offices (for emergency coordination), and emergency shelters, the solution could serve these critical facilities. This assumes a combined critical load across all buildings of 595 kW[23] for an extended period of days to weeks, depending on the availability of diesel delivery service for the backup units. In the case of no available fuel for backup generators, the proposed solar-battery system could support the critical loads for 8 hours to multiple weeks for each stakeholder location, depending on its load and the available solar PV installation potential.

All the stakeholders are configured to be disconnected from each other and run independently as building-level microgrids to reduce the energy exchange and operation complexity for reliability purposes.

4.1.4 Interconnection with Utility Grid

The behind-meter DERs proposed for each site will be interconnected to the Eversource distribution grid at their interconnection point. Each stakeholder location can be operated independently in an islanded mode in the proposed configuration.

[23] Assuming 70% of Wilson Middle School peak load and 100% of Natick Water System peak load are critical load.

The local distribution grid and controls will be based on a combined solar-battery system with switches, reclosers, circuit breakers, and relays to prevent fault currents or back feeding from damaging the grid infrastructure or sensitive loads. Relays can be connected to allow fault isolation and automated reclosing and provide grid data to the Supervisory Control and Data Acquisition (SCADA) system.

4.2 Load Characterization

4.2.1 Summary of the NCRS Loads

The hourly granular electricity loads are available for WMS and the A Street Pumping Station. Only historical monthly usage and billing data are available for Fire Station #2. These stakeholders' average, peak, and critical loads were collected through a request for information (RFI) or a resiliency survey, summarized in Table 10.

Table 10. NATICK Average, Peak, and Critical Electrical Loads

Stakeholder		Critical Buildings/Loads	Average Load (kW)	Peak Load (kW)	Critical Load (kW)
WMS		Elevator, security lighting, fire panel,	38.2	193.7	135
Natick Water System	STVP	All loads, whole facility should be treated as critical load	186.8	406.2	406.2
	EW		19.7	42.8	42.8
	TF		2.9	6.4	6.4
	BH		2.3	5	5
	Total		250	654	595

4.2.2 Loads of Each Stakeholder

Wilson Middle School

The annual hourly electric load shape and peak day load shape of WMS are shown in Figure 16 and Figure 17, respectively. The average electricity load is 38 kW after 302kW roof-solar offset. Peak electricity load is around 194 kW. The load profile[24] on a sunny day with solar offset is shown in Figure 17. On average, WMS pays $0.175/kWh for electricity usage, including the energy cost from the power supplier and the delivery charge from the utility. The monthly thermal load and cost are shown in Figure 6. WMS's annual electricity and heating loads are 678,027 kWh and 38,975 therms. The monthly energy usage, cost, and demand for 2019 are shown in Table 11 and Figure 18.

[24] Town of Natick, MA-IDR_2884300013.xlsx

Figure 16. WMS Hourly Electricity Load Profile (2019)[25]

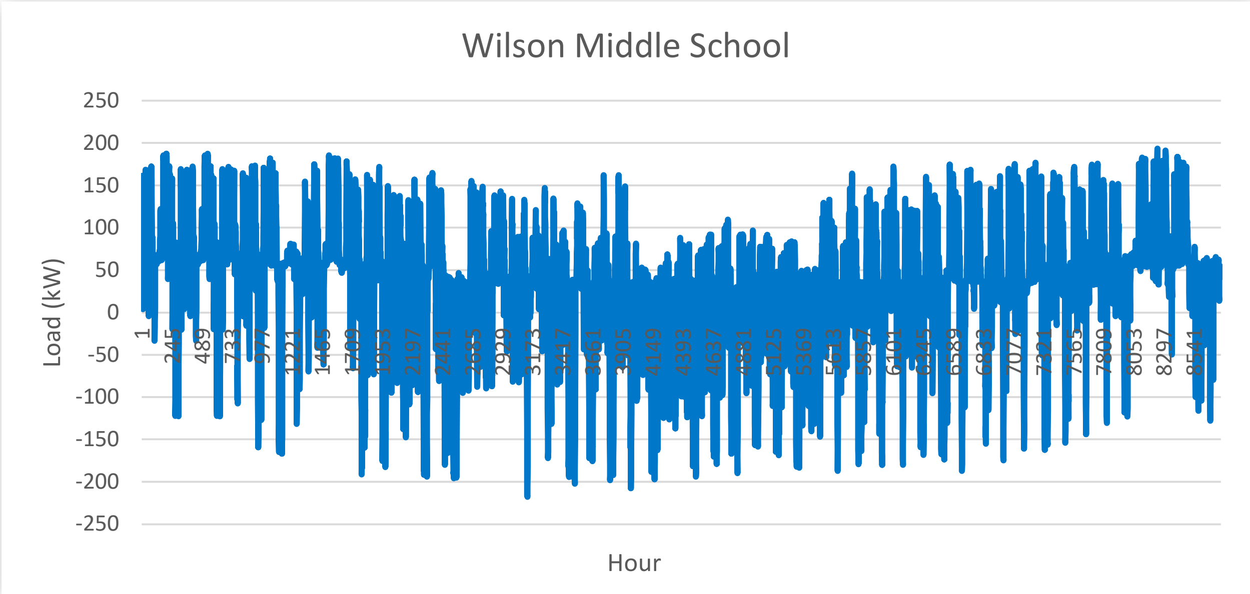


Figure 17. WMS Electricity Load Profile on a Sunny Day

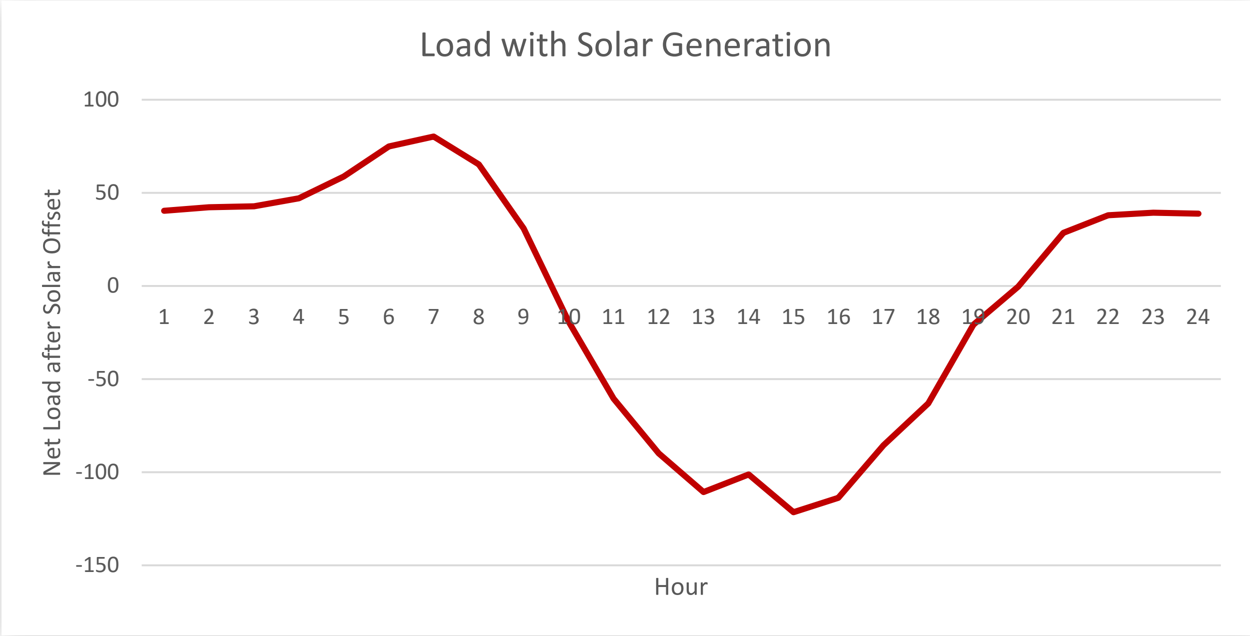


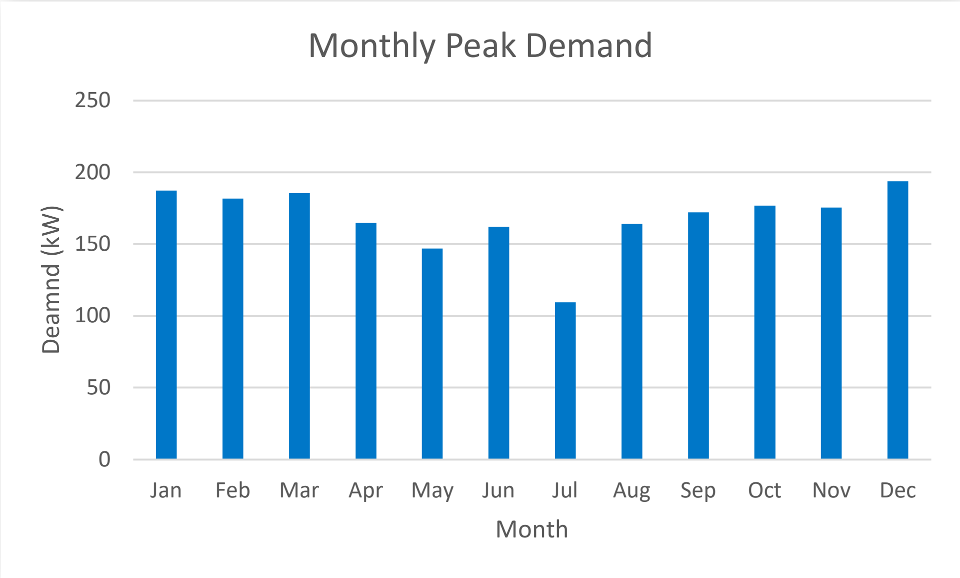
Table 11. Energy Usage and Cost for WMS (Year 2019)

Month	2019					
	Electricity Usage (kWh)	Electricity Cost ($)	Gas Usage (Therm)	Gas Cost ($)	Averaged Electricity ($/kWh)	Averaged Gas Cost ($/Therm)

[25] The existing 302kW roof-solar generation is included in the load shape

Jan	43,560	$4,866	7,299	8,117	0.11	1.11
Feb	48,510	$4,896	8,686	9,675	0.10	1.11
Mar	47,790	4,871	7,862	8,804	0.10	1.12
Apr	26,880	4,239	5,679	6,347	0.16	1.12
May	22,200	3,962	2,367	2,870	0.18	1.21
Jun	14,400	4,160	702	1167	0.29	1.66
Jul	-1,410	5,245	117	143	N/A	1.22
Aug	7,410	4,483	88	102	0.60	1.16
Sep	12,660	4,836	102	136	0.38	1.33
Oct	21,960	5,461	367	820	0.25	2.23
Nov	34,830	4,600	1,573	2,930	0.13	1.86
Dec	45,060	4,991	4,133	4,008	0.11	0.97

Figure 18. WMS Monthly Electricity Demand



Natick Water System

Springvale Treatment Plant

The hourly load shape for SVTP is shown in **Figure 19,** with an average electricity load demand of 187 kW. The hourly load shape in peak load data is shown in **Figure 20**. The annual electricity usage is 1,707,272 kWh, and the cost is $310,034, respectively.

Figure 19. Springvale Treatment Pant Hourly Electricity Load Profile

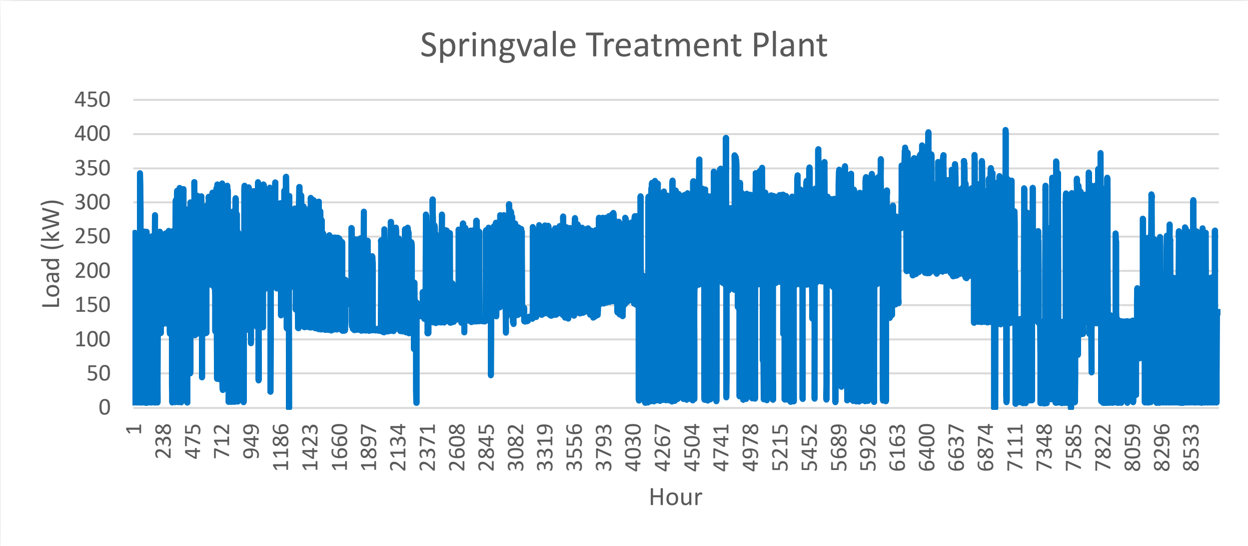


Figure 20. SVTP Hourly Electricity Load Shape in Peak Load Day

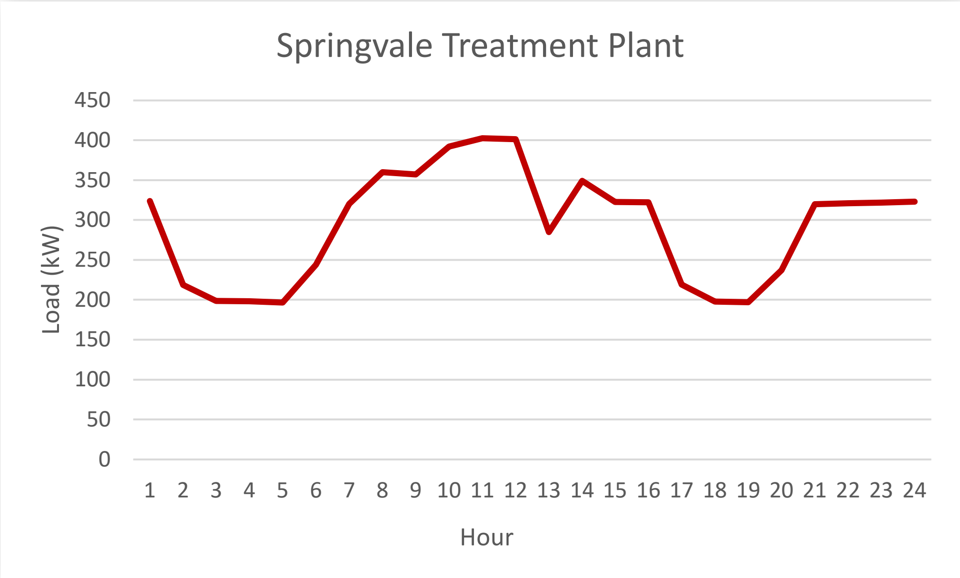


Table 12. Energy Usage and Cost for SVTP (Year 2019)

Month	2019					
	Electricity Usage (kWh)	Electricity Cost ($)	Gas Usage (Therm)	Gas Cost ($)	Averaged Electricity ($/kWh)	Averaged Gas Cost ($/Therm)
Jan	156,592	26,194	2161	2159	0.17	1.00
Feb	157,352	26,576	2316	2308	0.17	1.00
Mar	144,448	24,850	2170	2144	0.17	0.99
Apr	129,448	23,415	1765	1751	0.18	0.99
May	125,928	22,060	765	734	0.18	0.96

Jun	136,120	23,168	353	292	0.17	0.83
Jul	142,304	28,415	117	119	0.20	1.02
Aug	152,648	30,191	17	48	0.20	2.82
Sep	139,176	28,119	4	40	0.20	10.00
Oct	182,040	33,185	4	40	0.18	10.00
Nov	129,592	23,152	718	514	0.18	0.72
Dec	111,624	20,709	2045	2,322.00	0.19	1.14

Evergreen Wells, Town Forest Water Storage, and Broad Hill Water Storage

The hourly granular load data are not available for EW, Town Forest Water Storage, and Broad Hill Storage at the time of this report. Their hourly load shapes are estimated based on their annual load and the hourly shape of SVTP. The estimated load shapes for these three sites are shown in Figure 21-Figure 23.

Figure 21. EW Estimated Hourly Electricity Load Profile

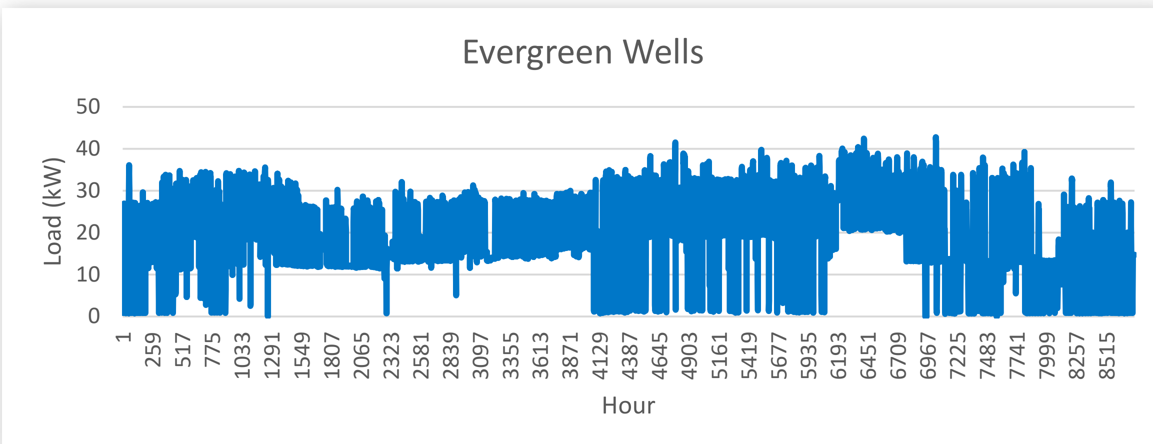


Figure 22. Town Forest Water Storage Estimated Hourly Electricity Load Profile

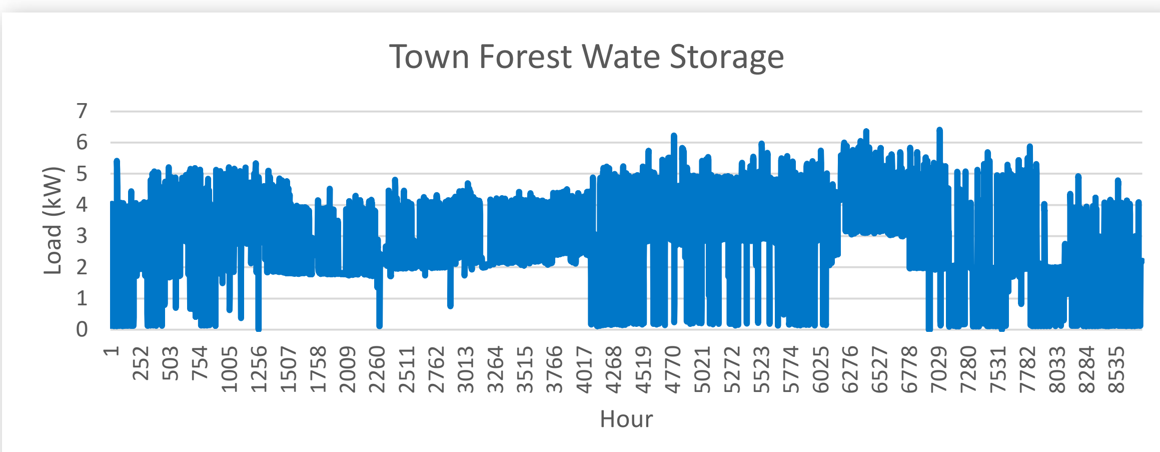
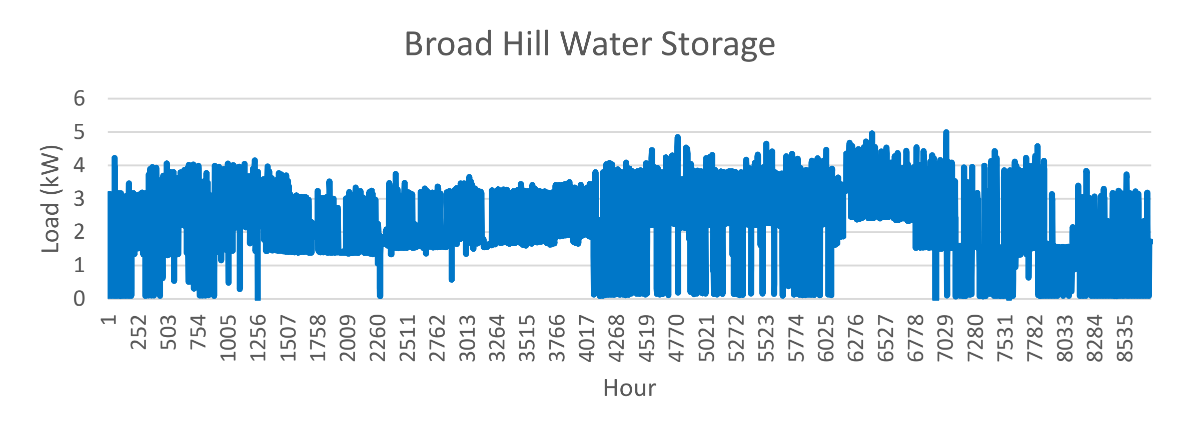


Figure 23. Broad Hill Water Storage Estimated Hourly Electricity Load Profile



4.3 Distributed Energy Resources Characterization

4.3.1 Description of Proposed DERs

It is assumed that the stakeholder would pay a fixed electricity rate of $0.0945/kWh based on the contract with Constellation New Energy (CNE)[26]. Transmission and distribution charges are paid to Eversource for electric delivery, and the rates and charges are different based on the service level of the accounts. Broad Hill Water Storage and Town Forest are under Tariff B1 based on the load scale and peak load. EW is associated with Tariff B2. WMS and Springvale Treat Plant are under Tariff B7. The demand charge is different for different seasons, i.e., summer peak season and winter off-peak season. The detailed demand charges, energy costs, and gas prices used in the modeling are summarized in Table 13 for the simulation.

Table 13. Price Parameter Used in Simulation

Tariff	Winter Energy Cost ($/kWh)	Summer Energy Cost ($/kWh)	Winter Demand ($/kW)	Summer Demand ($/kW)	Meter Charge ($/Day)
B1	0.17924	0.20825	0	0	0.367
B2	0.14119	0.15243	53.38	22.18	0.6
B7	0.09617	0.09617	24.44	33.99	3.67

*Summer: Jun-Sep, Winter: Oct-May

Two scenarios were simulated and presented with the aggregated hourly load profile and costs in this section. The preliminary cost-benefit analysis is summarized in Table 14. In Table 14, the incentives for solar and battery storage installation, such as federal tax credits, SMART solar, energy efficiency rebate/incentive programs, etc., are not considered in this section, but will be studied in the next section (Financial Solutions).

[26] Natick MA annual review of electricity supply costs_2020.pdf

7-day resiliency is also studied for each of the sites. On a black-sky day (when solar does not generate or the solar generation drops significantly), large battery storage would be needed to supply the critical load. For SVTP, as an example, over 30MWh battery would be needed to continually serve the load for seven days if onsite diesel backup generators are not available. This configuration is not economically viable based on the current battery storage prices. Battery sizes of 6.4MWh for WMS, 3.4MWh for EW, 500kWh for Town Forest Water Storage, and 340kWh for Broad Hill Water Storage are not economically viable based on the cost of the batteries. Therefore, it is more viable to use backup generators to supply the onsite load during long-hour grid outages instead of installing large battery storage.

On a typical day (blue sky), WMS would need around 400kWh battery storage to continually serve its critical load for up to 7 days. The size of the battery is due to the potential amount of onsite solar, which can offset 100% of the load. The potential 18kW solar PV in Broad Hill can offset up to 100% of its load; 60kW battery storage would enable the site's load ride-through grid outage for up to 7 days. The rest of the three sites: SVTP, EW, and Town Forest Water Storage, have either limited or no space for solar. Considerable battery sizes will be needed for these three sites if only the batteries are used to supply the load for long-hour periods, i.e., 7-day. Using onsite backup generation resources to serve the critical load during long hour grid outages would make more.

Table 14. NATICK Resiliency Solution Preliminary Configuration and Cost Analysis Summary

	Base	Resiliency	Economic
Technical Data			
Solar Capacity (kW)	-	347	347
Battery Capacity (kW/kWh)	-	845/3470	175/700
CO_2 Emission (metric ton)	728	639	642
CO_2 Reduction (metric ton)	-	89	85
Solar Generation (kWh)	0	417,795	417,795
Battery Charged by Solar (%)	0%	19%	73%
Current Annual Load (kWh)	2,189.075		
Load Offset by Solar (%)	0%	19%	19%
Islanding Capacity[27]		hours to multiple weeks varies for sites	
Preliminary Economic Data[28]			
Annual Electric Costs ($)	366,687	260,158	288,534
Annual Fuel Costs ($)	61,620	61,620	61,620
Annual Energy Cost ($)	428,307	321,778	350,154
Annual Energy Cost Saving ($)	-	106,529	78,153
Investment Cost (Battery) ($)	-	2,168,750	431,250
Investment Cost (Solar) ($)	-	1,128,075	1,128,075
Infrastructure Cost ($)	-	50,000	50,000

[27] Additional islanding capacity provided by new proposed DER mix before the onsite backup generators kick in.

[28] Infrastructure cost: the cost of cables, switch gear, meter, etc. in customer site that Utility don't have financial right. Investment cost: the installation cost of components includes both the hardware cost and labor cost. Project Administration Cost: the cost includes the cost administering, managing and coordinating, supervising the project

Total Investment Cost ($)	-	3,346,825	1,609,325
Project Administration Cost ($)	-	836,706	380,144
Total Project Cost ($)	-	4,183,531	2,011,656

The preliminary cost analysis for each stakeholder is presented in Table 15 through Table 19. The capacity value of battery storage has a significant impact on the payback year since a battery energy storage system (BESS) mainly provides reliability improvement benefits . BESS can reduce the demand charge cost but does not generate significant revenue based on the demand charge assumption for the Town of Natick configuration.

Table 15. NATICK Resiliency Solution Preliminary Cost Analysis (WMS)

WMS	Base	Resiliency	Economic
Technical Data			
Solar Capacity (kW)	-	275	275
Battery Capacity (kW/kWh)	-	250/1000	30/120
CO_2 Emission (metric ton)	68	0	0
CO_2 Reduction (metric ton)	-	69	69
Solar Generation (kWh)	-	335,444	335,444
Battery Charged by Solar (%)	0%	92%	100%
Current Annual Load (kWh)	334,733		
Load Offset by Solar (%)	0%	100%	100%
Islanding Capacity		Multiple weeks	4 hours
Preliminary Economic Data			
Annual Electric Costs ($)	78,828	13,909	32,252
Annual Fuel Costs ($)	45,119	45,119	45,119
Annual Energy Cost ($)	123,947	59,028	77,371
Annual Energy Cost Saving ($)	-	64,919	46,575
Investment Cost (Battery) ($)	-	625,000	75,000
Investment Cost (Solar) ($)	-	893,750	893,750
Infrastructure Cost ($)		10,000	10,000
Total Investment Cost ($)	-	1,528,750	978,750
Project Administration Cost ($)	-	382,188	244,688
Total Project Cost ($)	-	1,910,938	1,223,438

Table 16. NATICK Resiliency Solution Preliminary Cost Analysis (SVTP)

SVTP	Base	Resiliency	Economic
Technical Data			
Solar Capacity (kW)	-	54.1	54.1

Battery Capacity (kW/kWh)	-	500/2000	100/400
CO_2 Emission (metric ton)	416.0	400.9	403.7
CO_2 Reduction (metric ton)	-	15.1	12.4
Solar Generation (kWh)	0.0	60,707	60,707
Battery Charged by Solar (%)	0%	8%	42%
Current Annual Load (kWh)	1,636,066		
Load Offset by Solar (%)	0%	4%	4%
Islanding Capacity		10 hours	2 hours
Preliminary Economic Data			
Annual Electric Costs ($)	250,591	212,161	221,940
Annual Fuel Costs ($)	16,501	16,501	16,501
Annual Energy Cost ($)	267,092	228,662	238,441
Annual Energy Cost Saving ($)	-	38,430	28,651
Investment Cost (Battery) ($)	-	1,250,000	250,000
Investment Cost (Solar) ($)	-	175,825	175,825
Infrastructure Cost ($)		10,000	10,000
Total Investment Cost ($)	-	1,435,825	435,825
Project Administration Cost ($)	-	358,956	108,956
Total Project Cost ($)	-	1,794,781	544,781

Table 17. NATICK Resiliency Solution Preliminary Cost Analysis (BH)

BH	Base	Resiliency	Economic
Technical Data			
Solar Capacity (kW)	-	18	18
Battery Capacity (kW/kWh)	-	40/160	15/60
CO_2 Emission (metric ton)	4	-0.33	0
CO_2 Reduction (metric ton)	-	4	4
Solar Generation (kWh)	0.0	21,644.1	21,644.1
Battery Charged by Solar (%)		37%	99%
Current Annual Load (kWh)	20,120		
Load Offset by Solar (%)	0%	108%	108%
Islanding Capacity		Multiple weeks	24 hours
Preliminary Economic Data			
Annual Electric Costs ($)	4,404	1,399	1,480
Annual Fuel Costs ($)	0	0	0
Annual Energy Cost ($)	4,404	1,399	1,480
Annual Energy Cost Saving ($)	-	3,004	2,924
Investment Cost (Battery) ($)	-	150,000	62,500
Investment Cost (Solar) ($)	-	166,400	166,400
Infrastructure Cost ($)		10,000	10,000
Total Investment Cost ($)	-	326,400	238,900

Project Administration Cost ($)	-	81,600	59,725
Total Project Cost ($)	-	408,000	298,625

Table 18. NATICK Resiliency Solution Preliminary Cost Analysis (TF)

TF	Base	Resiliency	Economic
Technical Data			
Solar Capacity (kW)	-	0	0
Battery Capacity (kW/kWh)	-	10/40	5/20
CO_2 Emission (metric ton)	5.3	5.2	5.3
CO_2 Reduction (metric ton)	-	0.05	0
Solar Generation (kWh)	0.0	0.0	0.0
Battery Charged by Solar (%)		0%	0%
Current Annual Load (kWh)	25,836		
Load Offset by Solar (%)	0%	0%	0%
Islanding Capacity		12 hours	6 hours
Preliminary Economic Data			
Annual Electric Costs ($)	5,274	5,251	5,274
Annual Fuel Costs ($)	0	0	0
Annual Energy Cost ($)	5,274	5,251	5,274
Annual Energy Cost Saving ($)	-	23	0
Investment Cost (Battery) ($)	-	25,000	12,500
Investment Cost (Solar) ($)	-	0	0
Infrastructure Cost ($)		10,000	10,000
Total Investment Cost ($)	-	35,000	22,500
Project Administration Cost ($)	-	8,750	5,625
Total Project Cost ($)	-	43,750	28,125

Table 19. NATICK Resiliency Solution Preliminary Cost Analysis (EW)

EW	Base	Resiliency	Economic
Technical Data			
Solar Capacity (kW)	-	0	0
Battery Capacity (kW/kWh)	-	45/270	25/100
CO_2 Emission (metric ton)	35.1	83.2	84.0
CO_2 Reduction (metric ton)	-	-48.1	-48.9
Solar Generation (kWh)	0.0	0.0	0.0
Battery Charged by Solar (%)		0%	0%
Current Annual Load (kWh)	172,320		
Load Offset by Solar (%)	0%	0%	0%
Islanding Capacity		14 hours	5 hours
Preliminary Economic Data			
Annual Electric Costs ($)	27,591	27,438	27,589

Annual Fuel Costs ($)	0	0	0
Annual Energy Cost ($)	27,591	27,438	27,589
Annual Energy Cost Saving ($)	-	153	2
Investment Cost (Battery) ($)	-	168,750	56,250
Investment Cost (Solar) ($)	-	0	0
Infrastructure Cost ($)		10,000	10,000
Total Investment Cost ($)	-	178,750	66,250
Project Administration Cost ($)	-	44,688	16,563
Total Project Cost ($)	-	223,438	82,813

The primary generation source for the entire proposed solution would include the roof-top solar and solar canopy in the parking lot, with a total capacity of up to 347 kW; and battery storage, with a total capacity of up to 845 kW/3,470kWh for resiliency-focused scenario and 175kW/700kWh for the economic-focused scenario. Battery storage would be charged by solar generation during daytime and discharged for supplying load during the night or charged during off-peak periods and discharged during high-demand cost periods under a time of use or real-time pricing rate.

Locations and space available for solar are shown in Figure 24 through Figure 26, matching the totals in Table 9. Adequate space was identified during the site visits conducted during Task 2. Larger batteries (over 500-1,000 kWh) should be in NEMA-rated enclosures with integrated temperature control and fire protection at outside locations.

Figure 24. WMS (275 kW) (Blue Circles with AC/DC inside represent the Inverter[29])

[29] https://www.helioscope.com/

Figure 25. SVTP (54.1 kW)

Figure 26. BH (18 kW)

4.3.2 Ability of DERs to Serve Load and Provide Resilience

During normal operating conditions, i.e., grid-connected mode, the proposed generation resources would operate in parallel to the grid. Approximately 19% of the load would be met by local distributed generation (Solar PV), while the remaining electricity would be purchased from the utility.

Installation of DER assets would consider flood and storm risks, and they would be rated accordingly. Modern solar panel rooftop racking is highly resistant to weather conditions and can be rated for 120 mph winds and greater. Switchgear and other electrical infrastructure will be raised above flood levels to prevent equipment malfunction due to climate change. Traditional generation and battery equipment will be installed indoors or in weather-rated containers.

The DER controller would coordinate and dispatch the charge activity of battery storage and dispatch the energy generated by DERs located at each location.

4.3.3 Fuel Sources for Fossil Fuel DERs

Eversource Energy is the current natural gas supplier for the project area. If the diesel supply is disrupted, the critical loads will continue to be electrically served by solar and storage. The resiliency-oriented solution could provide unlimited islanding capacity for BH and weeks for WMS in typical weather conditions, around 10 hours for SVTP, EW, and TF due to either limited or unavailable solar installation space.

4.3.4 DER Capabilities

The microgrid controller enables the DERs to respond quickly to energy needs, change ramp direction on demand, sustain up/down ramping for extended periods, start/stop multiple times a day, respond for defined periods of time on request, start with a short notice from zero or low-electricity operating level, and forecast operating capability through the economic dispatch and real-time management of DERs such as solar and battery storage. This includes maintaining voltage and frequency in grid-following mode and utilizing battery and solar inverters to ride through islanding and resynchronization events. According to IEEE 2030.7 standards, controls will be done following the IEEE 2030.8 guidelines.

4.4 Electrical and Thermal Infrastructure Characterization

Whenever possible, the existing overhead/underground distribution cables will be used to connect the different microgrid stakeholders. The overhead distribution cables connecting the three sites could be changed to underground cables to increase resiliency further.

4.4.1 Simplified Electrical and Thermal Infrastructure Diagram

The conceptual simplified infrastructure diagram is presented in Figure 1. The connected substation and feeder for each stakeholder are summarized in Table 20. The different feeders feed the five sites.

Table 20. Summary of Distribution System (Substation, Feeder, and Capacity)

Stakeholder		Study Area	Voltage (kV)	Location Hosting Capacity (MW)
WMS		Natick	13.8	1
Natick Water System	SVTP		13.8	0.5
	EW		13.8	0.05
	TF		4.16	0.05
	BH		13.8	0.7

4.5 Resiliency-focused solution and Building Controls Characterization

The proposed solution will demonstrate several recent technological advancements and breakthroughs to help the stakeholders achieve their energy goals. The critical is the methodology that synchronously considers both system planning and simulated operation. The proposed methodology supports a high penetration of intermittent renewable energy resources by introducing a controllable and flexible load.

4.5.1 DER Controls

The primary controls[30] are within each of the devices offering localized control in real-time. These controls are designed to realize load sharing among parallel-connected DERs with no need to provide communication channels between DERs.

The secondary control is disabled in grid-connected mode since the utility grid maintains the voltage. In islanded mode, the secondary control would eliminate voltage deviations without adjusting the dispatch of parallel DERs. Once a voltage deviation is detected, the secondary control would generate a voltage compensation signal to uplift the droop curve and restore the rated voltage without changing the DER dispatch.

The economic and optimal operation of DER necessitates an upper-level tertiary control. The master controller is mainly responsible for tertiary control for optimal operation and dispatch.

This configuration will provide reliability for serving stakeholders while satisfying Eversource's requirements by using proven technologies. It will allow the planning technology stack to analyze and optimally size and site DERs in the project area.

4.5.2 Services and Benefits

NCRS would provide an extra layer of resiliency benefit paired with the existing backup generators. The NCRS will provide 10 hours to multiple weeks of backup and islanding capacity using the proposed clean solution that varies by site. Longer hours for WMS and BH with large solar PV or smaller load; shorter hours for STVP, EW, and TF due to limited or unavailable space for solar installation. The proposed solution will provide benefits and values in grid-connected and islanded modes. The grid-connected mode includes ancillary services, power quality services, quality of services, intermittency alleviation, and reliability improvement to sensitive loads such as security systems. Islanded mode includes black-start and resiliency; non-energy related and societal benefits such as workforce training, emerging technologies evaluation testbeds, and other smart grid services.

The proposed solutions will demonstrate how to use advanced data analytics in a resiliency-focused solution, specifically to defer generation, transmission, and distribution upgrade costs, which are passed on to ratepayers as cost reductions. This solution also will demonstrate how integrated DER controls can respond to load-following and ramping needs at the local grid and system levels. This solution will lower bills, provide more reliable energy services, and lead to a cleaner environment for the project stakeholders. As described below, the proposed project will benefit stakeholders with greater reliability, lower costs, and increased safety.

4.5.2.1 Improved Reliability

[30]Primary control: based on the droop characteristics of DER units for sharing the microgrid load
Secondary control: performs corrective action to mitigate frequency and voltage errors introduced by droop control
Tertiary control: manages the flow between the microgrid and the utility grid and provides the optimal scheduling of DER units and demands for both islanded and grid-connected operation of the microgrid
L Che, M Khodayar, M Shahidehpour, "Only connect: Microgrids for distribution system restoration," IEEE power and energy magazine, 2013

a. This solution is designed to incorporate high DER penetration. Under this design, even if a few DERs fail, the rest of the DERs within the system will remain operational, ensuring system stability and reliability.
b. The proposed solution will provide ISO-NE and Eversource with DER visibility, supporting daily operations and providing their customers with higher reliability.
c. The proposed solution has the islanding capability to continue to function in an electric grid disruption, increasing grid stability and power quality.
d. This solution uses renewable energy sources, decreasing dependency on natural gas-powered peak plants, and is subject to supply disruptions.

4.5.2.2 Potential Energy and Cost Savings

a. Energy efficiency with renewable generation lowers power procurement, generation, utility, and stakeholder costs. It can defer peak power plant, transmission, and distribution infrastructure upgrade costs. On a broader scale, lowering these costs could help result in future decreases in Eversource's ratepayer costs.
b. It will provide efficient real-time operational schemes that allow DER operators to monitor and manage the generation assets more economically and efficiently.
c. It provides the utility with visibility, enabling more efficient operation (e.g., grid-level DER dispatch) and grid services (e.g., ramp up/down, support more storage, less intermittency, and generation curtailment).
d. Optimally dispatching load demand with the battery storage dispatch and solar PV generation at each location would result in demand charge savings, energy savings, and maximized utilization of solar generation and load demand response.

4.5.2.3 Safety

a. This proposed project will lower the running hours of backup diesel or gasoline generators and reduce natural gas use. An added benefit is minimizing stress on the current aging natural gas infrastructure.
b. This project would lower the baseload and provides peak shaving.
c. It provides an alternate energy source, decreasing the impact of potential incidents, such as gas leaks.
d. It will provide power to the designated emergency shelters during prolonged grid disruptions caused by natural disasters (e.g., winter storms, fires, heat waves, and floods).
e. The provided visibility increases safety for maintenance workers investigating system faults by showing the shortest path to correct the fault.

4.5.3 Load Management and Resilience

The proposed solution can supply power to critical facilities from battery storage and local DERs to improve critical facilities' energy resilience. In extreme weather events, if one DER fails due to less generation, the loads can be served by the generation resources located at the same site. With the proposed solar PV and battery storage in each site, the energy consumption and demand could be managed effectively. More reliable and resilient power service could be achieved by dispatching DER assets and load in all stakeholder locations.

4.6 Information Technology (IT)/Telecommunications Infrastructure Characterization

Modern utility or system operators rely heavily on their communication infrastructure to monitor and control their grid assets. This architecture enables real-time control, the rapid digestion of critical grid information, and historical data for analysis and reporting.

4.6.1 IT/Telecommunications

Building management systems rely on BACnet, Modbus, or Lonworks (ISO/IEC 14908) over serial or Ethernet. Controls for chillers, boilers, distributed heating systems, thermostats, air-handling units, lighting, and others use various wired or wireless networks and protocols, depending on when purchased or upgraded. Often, vendor-specific proprietary networks are deployed as technology progresses with little regard for data consolidation. Networks are set up for research and operations with IT departments, especially in a campus environment. They often struggle to maintain services and prevent attacks rather than consolidate various networks and devices.

With the development of the proposed solution, existing communications and control infrastructure will be leveraged to avoid re-training operators and excess capital expenditures. This is possible due to OSISoft's PI Historian framework, which integrates every major vendor's proprietary protocol and standard protocol and has been tested and integrated with billions of devices. This includes building and lighting controls, generators, and any other equipment that DER owners or personnel want to monitor from one easy-to-search, easy-to-access system.

Public access to the high-level generation and operation of the system can be granted through a simplified online portal or on-campus display to allow for education and community engagement.

4.6.2 IT/Telecommunications Operation

The grid operations equipment, i.e., circuit breakers, relays, reclosers, and other switchgear, are vital to controlling the proposed DER mix. While some distributed switchgear can utilize wireless infrastructure, with data being fed through utility substations, the control equipment is more vital to the safe operation of the control and operation. It would ideally use a fiber-optic backbone between the controller and controllable components. Once collected locally, the data will be fed into an upgraded or added SCADA system to allow operators to access, visualize, and control all the DER assets from a central control center located on or off the campus. Exact upgrades or additions to existing communications infrastructure will need to be determined during a detailed design phase.

If an O&M firm is contracted, they can be responsible for the communications infrastructure and associated electrical and controls equipment critical to the operation. Suppose the Town of Natick decides to hire staff and operate the system itself. In that case, the existing IT department will be trained on the maintenance and operation of the communications system.

Additionally, Eversource could use its own backhaul network to bring DER operations data back to its emergency operations center if it plans to leverage the resiliency solution for a black-start capability to re-energize its lines. In the case of operating or controlling the DER asset within the proposed solution, Eversource would need to send the request to the DER controller through which the control commands are sent to the target units. The proposed solution would provide Eversource or other regulation departments with an interface to oversee or monitor the DER running status for grid reliability and stability.

4.7 Conclusion

In the proposed solution, the generation resources in different stakeholder locations would be optimally dispatched and controlled to provide economic benefit and better resiliency in service for current customers toward zero-emission communities. The proposed clean resiliency-focused solution would improve power supply reliability and resiliency and provide a clean, green energy service for current communities and customers.

Following Section 3 (Task 2), a preliminary technical design and system configuration was proposed per the site assessment findings and characteristics identified in Section 2. The proposed DERs planned to be operated in the NATICK were discussed. The current and proposed electrical infrastructure were studied, along with preliminary costs for each site. The proposed solution's characterization of the controller, services, and benefits were described.

The current annual energy costs and CO_2 emissions for the existing loads are calculated to be $428,000 and 728 metric tons, respectively. This represents the baseline for the proposed solution. Compared with the base case, the proposed clean resiliency solution would have a 24.9% annual energy cost saving and 12.2% of annual CO2 emissions saving. Additionally, the annual CO_2 emission reduction compared to the base case is 89 metric tons.

5. Financial Solutions

5.1 Financial and Economic Analysis Objectives

The proposed project includes solar PV and battery storage DERs and other efficiency enhancements within the microgrid system. The installation would seamlessly integrate key objectives of the CLEAR Program (described above) and the Town's Municipal Vulnerability Preparedness (MVP) plan (2019), which identified initiatives to increase resiliency and reduce impacts from utility outages, GHGs, and energy costs.

5.2 Microgrid Development & Investment Trends

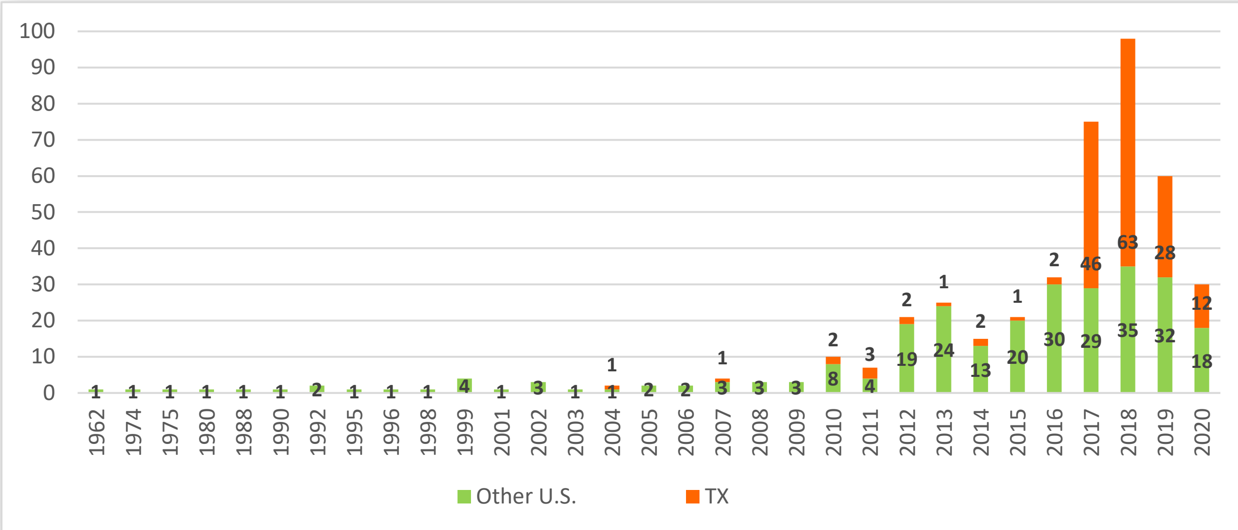
This section informs the Town of Natick's evaluation of microgrid installations on public property. The following overview of development and investment trends provides a brief history of the geographic expansion, purposes, and ownership structures that influence the current state of the microgrid market.

5.2.1 History of U.S. Microgrid Development

According to U.S. Department of Energy (DOE) data[31] illustrated in Figure 27 and Figure 28, approximately 461 active microgrid projects in the United States contain 821 distributed energy resources (DERs). Texas leads the nation in installations, followed by California, New York, Hawaii, and Massachusetts. Combined, these states and the Commonwealth account for nearly 60% of the total installations in the U.S. and its territories.

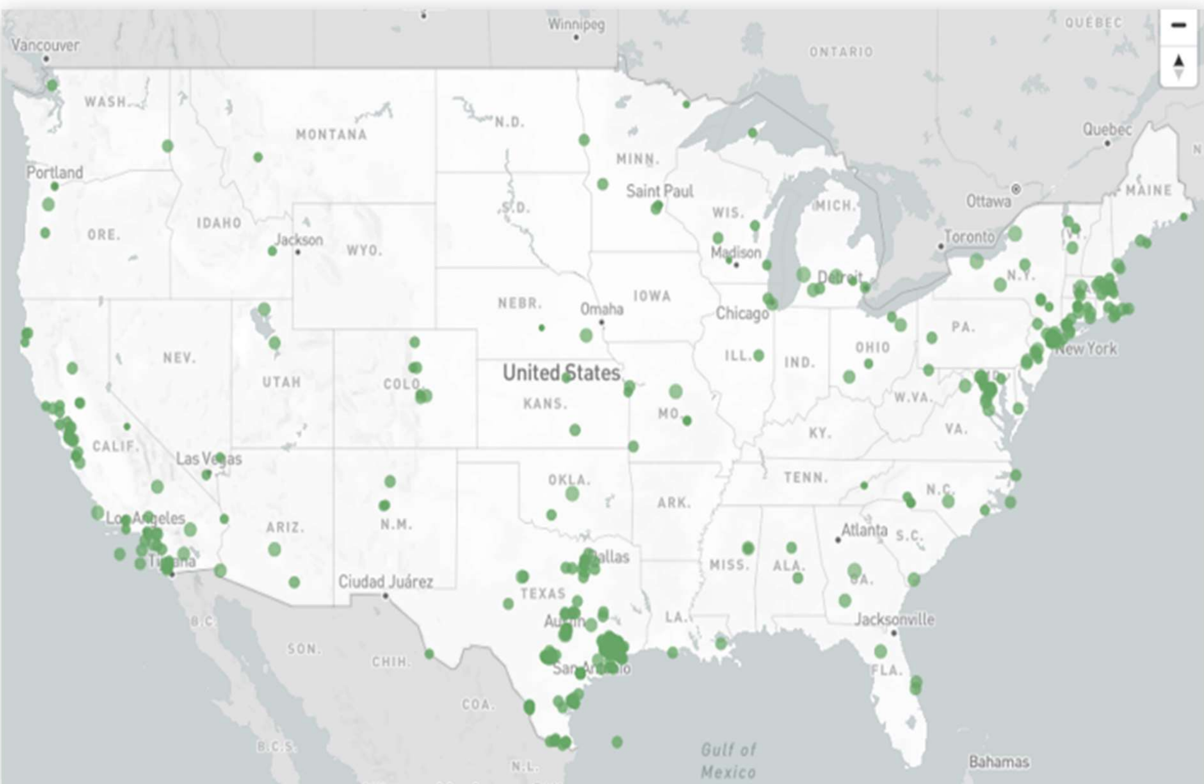
[31] https://doe.icfwebservices.com/microgrid

Figure 27. Active U.S. Microgrid Projects by Year of Construction



Source: https://doe.icfwebservices.com/microgrid; Willdan, 2021

Figure 28. Active U.S. Microgrid Projects by State



Source: U.S. Department of Energy; Willdan, 2021

Commercial deployments are the largest setting for microgrids, accounting for 42% of the U.S. total. This figure is skewed by the development of microgrids by H-E-B supermarkets in Texas, which began deploying microgrids in the Houston market to address power-related operational costs (spoilage).

The aftermath of Hurricane Harvey (late August 2017) tested the chain's ability to maintain operations at multiple Houston stores for several days following that event. The storm knocked out power for 300,000 utility customers[32]. Eighteen stores received full-facility backup power for five consecutive days during the storm. This led to the expansion of its microgrid program across the company, marketing "reliability as a service."

Table 21. U.S. Microgrid Installation Settings

	U.S. Total	%	Total w/o TX	%
Commercial	194	42%	51	17%
Town/Community	57	12%	55	19%
Military	49	11%	47	16%
College/University	44	10%	41	14%
Schools	27	6%	27	9%
Hospital/Healthcare	22	5%	19	6%
Public Institution	16	3%	16	5%
Research Facility	16	3%	13	4%
Multi-Family	15	3%	14	5%
Water Treatment/Utility	9	2%	2	1%
Agriculture	8	2%	8	3%
Other	4	1%	4	1%
TOTAL	461	100%	297	100%

Source: U.S. Department of Energy; Willdan, 2021

Excluding the Texas data, commercial, Town/community, military, and college/university deployments are the primary settings, accounting for approximately two-thirds of the 297 microgrids in the remainder of the U.S.

Natural gas turbines are the most common energy resource, totaling 191 and accounting for 23% of all microgrid resources. Within this total, there are 121 H-E-B natural gas microgrids in Texas.

Outside of Texas, natural gas totals 41, or 6% of the total U.S. microgrid energy resources. Dominant technologies are solar and battery storage, accounting for more than half of the non-Texas total.

Table 22. U.S. Microgrid Total Distributed Energy Resources

	U.S. Total	%	Total w/o TX	%
Natural Gas	191	23%	41	6%
Solar	181	22%	175	27%
Storage	171	21%	165	26%
CHP	102	12%	98	15%
Diesel	92	11%	82	13%
Wind	35	4%	35	5%
Fuel Cell	15	2%	15	2%
Unknown	13	2%	13	2%
Biogas	13	2%	13	2%
Hydro	5	1%	5	1%
Thermal	3	< 1%	2	< 1%
Total	821	100%	644	100%

[32] https://microgridknowledge.com/h-e-b-microgrid-hurricane/

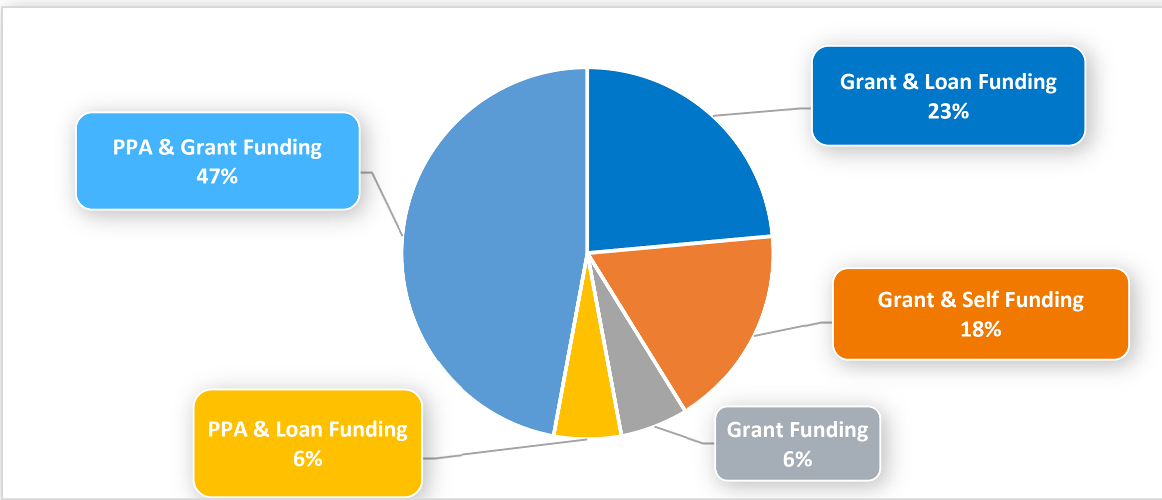
Source: U.S. Department of Energy and Willdan, 2021

5.2.2 Microgrid Funding Trends

Willdan conducted case study research on 93 microgrid projects throughout the U.S to evaluate microgrid financing alternatives. The research concluded that the most common form of financing is the Power Purchase Agreement (PPA).

Of those with detailed funding information, nearly half of all microgrid project deals utilized a combination of grant and PPA financing. Another 23% utilized a combination of grant and loan funding, while 18% included a combination of self-funding and grants, as shown in Figure 29.

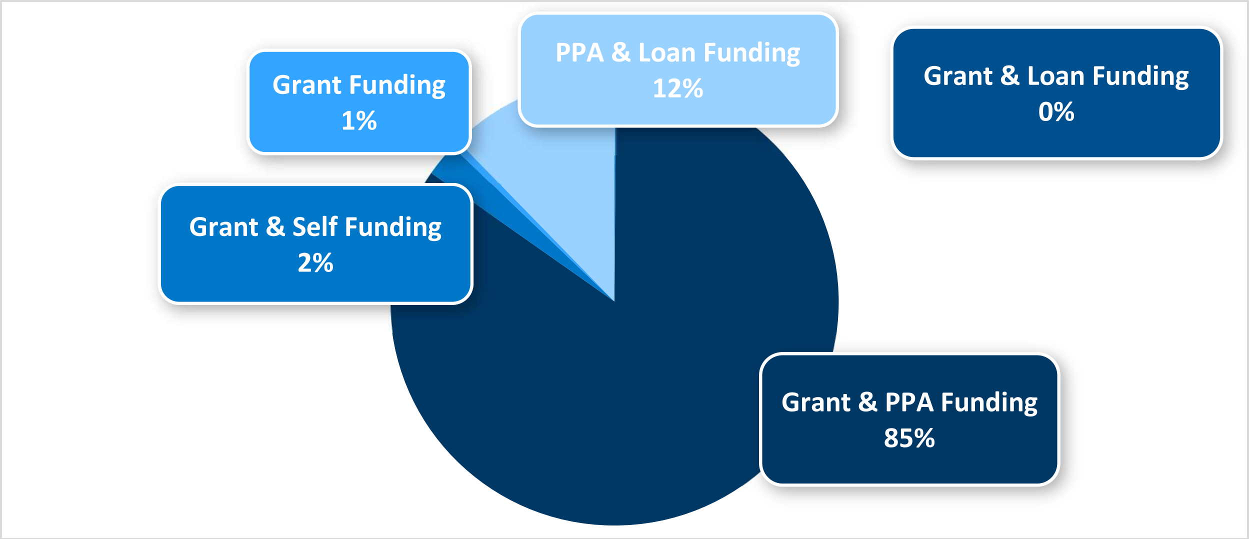
Figure 29. Volume of Microgrid Project Deals by Funding Source



On a dollar volume basis, the following figure illustrates that PPAs are the dominant funding source in the industry, providing 97% of the total capital investment analyzed within the case study projects (the sum of PPA & Loan Funding plus Grant & PPA Funding).

The disparity between the distribution of deals by funding category and the quantity of capital deployed perhaps exposes the challenge of raising capital outside of a PPA structure or, conversely, the relative ease of PPA financing. In the rare cases where non-PPA sources are utilized, the data indicate that the deals have much smaller capital needs.

Figure 30. Volume of Microgrid Dollars Invested by Funding Source



5.2.3 Trends in Ownership Structures

By virtue of the dominance of PPA financing, third-party ownership is the most common structure. A PPA is the only ownership structure that would enable a public entity to participate in downstream benefits from federal incentives. The importance of the federal investment tax credits and depreciation benefits cannot be overstated as a key consideration for the ownership structure. These items represent significant potential sources of investment cash flow that are not available to the public sector.

Every funding mechanism has its pros and cons. Elements of traditional infrastructure funding mechanisms (i.e., Special-Purpose Vehicles, Build-Operate-Transfer (BOT) models, and Public-Private Partnerships (PPPs)) are embodied in the agreements themselves. They are unwieldy for the projects studied in this report.

For example, PPA agreements may stipulate buy-back provisions at key junctures, likening them to a BOT. Special-purpose vehicles are generally unnecessary, as their primary benefit of moving the investment transaction "off-balance-sheet" is de facto accomplished by a PPA or other third-party mechanism.

PPPs are typically deployed for complex projects with significant capital needs ($100M+) and timelines often multiple times longer than PPA deal terms, typically running for 20 years or less.

5.3 Potential Funding Alternatives

5.3.1 Direct Funding

Ownership through direct funding via the Capital Improvement Planning (CIP) and/or General Fund (GF) could include a mix of capital sources, including direct budget appropriations, general obligation bonds, revenue bonds, grants, green bonds, and other opportunities that are described below (refer to **Appendix B:** State & Federal Grant Programs, Incentives, and Capital Enhancements for detailed background information).

Direct public ownership allows the owner (Town) to fully realize the full operational revenue stream and direct the deployment of those assets (i.e., how the energy resources are used). However, it eliminates the substantial benefits arising from federal investment tax credits (see ITC description in Section 5.8.1) and depreciation. Debt and budget capacities are also substantial considerations, as these sources are not always readily available. The expertise and workforce to maintain and operate the microgrid are still concerns or constraints. Public Works Departments may not possess the knowledge, skills, or expertise to effectively execute or invest in human capital.

Direct funding can be enhanced by utilizing various available tools to supplement investment capital or enhance or guarantee borrowing terms that facilitate the flow of capital.

5.3.2 Third-Party Funding Mechanisms

In addition to traditional funding through a combination of public debt and equity, other financing mechanisms can utilize third-party capital. However, this shifts ownership and most, if not all, operational control. These structures include Energy Services Agreements, the recently enacted Massachusetts SB-9, PACE financing, and the more commonly deployed Power Purchase Agreement (PPA). Each of these is described in further detail below and Appendix B: State & Federal Grant Programs, Incentives, and Capital Enhancements.

Power Purchase Agreement

A PPA is a financial agreement where a developer arranges to design, permit, finance, and install an energy system on a customer's property at little to no upfront capital cost. The developer sells the power generated to the host customer at a fixed rate that is typically lower than the local utility's retail rate. This lower electricity price offsets the customer's purchase of electricity from the grid. At the same time, the developer receives the income from the sale of electricity and any tax credits and all incentives generated from the system unless modified contractually.

PPAs typically range in duration from 10 to 25 years. The developer remains responsible for the operation and maintenance of the system for the duration of the agreement. At the end of the PPA contract term, a customer may be able to extend the PPA, have the developer remove the system, or choose to buy the solar energy system from the developer.

PPAs are among the most common forms of financing infrastructure because there is usually a high upfront cost that the host cannot afford. Choosing a PPA also means that the host is not responsible for the maintenance and saves money throughout the PPA. However, usually at the end of the leased agreement, the infrastructure has reached its useful life and needs to be replaced, so the host does not benefit much after the PPA.

The PPA provider is the owner of the assets through the term of the agreement and will seek to retain future incentive savings from programs that do not currently exist. This may preclude the host from claiming environmental benefits against targets (e.g., greenhouse gas reductions or carbon markets).

As these deals are typically longer-term, consideration should also be given to the host's ability to affect future changes to buildings or property where the assets are sited.

Energy Services Agreement

An Energy Service Agreement (ESA) is a pay-for-performance solution. An ESA is an off-balance-sheet financing solution that allows customers to implement energy efficiency projects with no upfront capital expenditure. The ESA provider pays for all project development and construction costs through the ESA. Once a project is operational, the customer makes service charge payments for actual realized savings. The price per unit of savings is a fixed output-based charge set at or below a customer's utility price, reducing operating expenses.

Unlike a PPA, customers do not assume performance risk since they only pay for the actual savings. Instead, the ESA provider takes the project performance risk and gets paid less if the project savings are less than expected.

Generally, an ESA is an effective tool for property owners looking to stabilize utility costs and make progress on their corporate social responsibility goals without making a large capital outlay. While ESAs offer long-term benefits due to the ability to buy out the contract and take ownership of the installed equipment, their primary benefit is the flexible nature of the contract structure. An ESA allows the host entity to reduce energy consumption within facilities with minimal management and little to no upfront costs.

Massachusetts SB-9

In March 2021, Governor Baker signed Massachusetts Senate Bill 9 (SB-9) legislation into law. The bill outlined comprehensive climate change legislation to meet the Commonwealth's commitment to achieving net zero emissions by 2050 and interim targets of 50% by 2030 and 75% by 2040. The legislation also authorizes the Secretary of Energy and Environmental Affairs (EEA) to establish emissions limits every five years and sector limits for electric power, transportation, commercial and industrial heating and cooling, residential heating and cooling, industrial processes, and natural gas distribution and service.

Other provisions of the bill:

- Increase the percentage of electricity from renewable sources by 3% annually between 2025 and 2029 to achieve a 40% overall target by 2030
- Raise the state's total target of offshore wind to 5,600 MW by authorizing 2,400 additional MW of additional capacity
- Improve access to solar for low-income communities by establishing a solar program trust
- Enhance gas pipeline safety
- Create a pilot program to deploy geothermal heat pumps within micro-districts
- Include the importance of equity and reductions in greenhouse gas emissions among the Department of Public Utility's existing priorities for safety, security, reliability, and affordability
- Require municipal light plants, which serve specific cities or towns, to purchase 50% of their power from non-carbon sources by 2030 and achieve net-zero emissions by 2050
- Provide local property tax exemptions under certain situations (see Local Property Tax Exemption)

A pertinent element of SB-9 is a provision that makes electric and gas distribution companies eligible to assist a municipality at high risk from climate change by constructing, owning, and operating solar PV and energy storage facilities on land owned by the electric or gas distribution company within a municipality. Focus is given to those municipalities with environmental justice populations. These facilities are built at no cost to the town and may receive DPU approval for cost recovery.

This change is significant, as distribution companies were previously prohibited from owning generation assets. The provision also limits the amount of energy to 10% of the total installed megawatt capacity of the Commonwealth’s solar generation facilities as of July 31, 2020.

Petitions for the development and cost recovery of utility-owned solar facilities must demonstrate site-specific environmental or climate change benefits to the community, municipality, or the Commonwealth. They are required to demonstrate consistency with the Commonwealth’s energy policies, contribute to the climate change resiliency of the host municipality, and mitigate peak energy demand.

At the time of this writing, there are no known petitions or completed developments for utility-owned solar PV installations or associated battery storage. Importantly, the ability of a municipality to direct the energy produced to any single asset or location(s) may be limited in this ownership context.

PACE

The Property Assessed Clean Energy (PACE) model is an innovative mechanism for financing energy efficiency and renewable energy improvements on private property. PACE programs exist for commercial properties (C-PACE) and residential (R-PACE). PACE programs allow a property owner to finance the up-front cost of energy or other eligible improvements on a property and then pay the costs back over time through a voluntary assessment. The unique characteristic of PACE assessments is that the assessment is attached to the property rather than an individual.

PACE financing for clean energy projects generally is based on an existing structure known as a "land-secured financing district," often referred to as an assessment district, a local improvement district, or other similar phrases. In a conventional assessment district, the local government issues bonds to fund projects with a public purpose, such as streetlights, sewer systems, or underground utility lines.

The recent extension of this financing model to energy efficiency and renewable energy allows a property owner to implement improvements without a large up-front cash payment. Property owners that voluntarily choose to participate in a PACE program repay their improvement costs over a set period—typically 10 to 20 years—through property assessments, which are secured by the property and paid as an addition to the owners' property tax bills. Nonpayment generally results in the same repercussions for failure to pay any other portion of a property tax bill, including loss of property.

5.3.3 Grants and Capital Enhancements

Following is a summary list of grant funding programs and cost-of-capital reductions. The detailed descriptions of their purposes, eligibility criteria, and other details are provided in Appendix B: State & Federal Grant Programs, Incentives, and Capital Enhancements.

- Biden Bipartisan Infrastructure Law (Infrastructure Investment and Jobs Act 2021)

- Building Resilient Infrastructure and Communities (BRIC) Grants
- DOE Loan Guarantees
- EPA Grants
- Green Bonds
- Green Banks
- Massachusetts Clean Water Trust
- Property Assessed Clean Energy (PACE)
- Massachusetts SB 9 (Net Zero Emissions by 2050)

5.4 Operational Benefits, Incentives, and Other Cash-Flow Opportunities

Energy companies and ISOs (see ISO) often maintain a variety of market-based opportunities that can monetize microgrids and their energy resources. It could be as simple as a solar PV array selling energy directly into the grid or as complicated as demand response (peak shaving), where energy is actively managed (called) to ensure adequate energy supplies and balance energy loads on the grid.

Specific to the NCRS, it is anticipated that the secondary market opportunities will likely focus on the Clean Peak Energy Credits (CPECs) Program and Demand Response, where the full, available capacity of both the solar PV and battery energy storage can be utilized for both purposes simultaneously, eliminating mutual exclusivities that arise with other options.

In addition, third-party ownership will enable the capture of Federal ITCs and depreciation benefits. Several additional secondary market opportunities that could generate financial benefits are less likely and more complicated due to mutual exclusivity challenges associated with the deployment of the stored battery energy and increased operational complexity. These challenges would not necessarily preclude participation but make it less likely given the financial upside of the "more likely" programs listed above. These additional opportunities detailed in **Appendix A:** Financial Analysis – Glossary of Terms include:

- Black Start Support
- Curtailment
- Clean Peak Energy Credits
- Depreciation
- Local Property Tax Exemptions
- Forward Capacity Market (FCM) Savings
- Frequency Regulation
- Regional Network Services (RNS)
- Reliability/Resiliency
- SMART Solar Incentives

5.5 Town of Natick Financing Requirements

Following data collection interviews with Town staff, Willdan validated the Town's key financial objectives to limit upfront capital outlay and ongoing operating responsibilities associated with microgrid development.

Based on these established funding plan parameters, third-party financing through a PPA is the recommended source of project capital. The following financial analysis is based on this understanding. It provides the respective deal terms for the Town of Natick and a PPA provider.

This analysis is structured to identify key financing assumptions and deal terms and, potentially, areas of negotiation for the Town.

5.6 Capital Cost Estimate

Capital costs are estimated from system sizing parameters presented in Section 4 and the current market cost per KW of capacity. These estimates assume that a third-party provider may be able to gain some volume purchasing power but will likely fall between the costs published in National Renewable Energy Laboratory's (NREL) *Annual Technology Baseline* report and general consumer pricing.

According to the NREL report, median solar PV costs for larger commercial applications decreased from $8,500 per kW in 2007 to $1,762 per kW in 2020, reflecting a 79% overall decrease and an average annual reduction of just under 13% per year.

Future annual cost reductions range between 2.0% and 9.0% for NREL's conservative and aggressive estimates, respectively, through 2030. After that, reductions range between 1.0% and 2.0%, reflecting the maturation of the market and the more conservative nature of long-range projections in a rapidly evolving technology space.

NREL's average price estimate for future battery energy storage reflects a similar level and pattern of reductions, with the unit cost for large-scale commercial applications decreasing from $1,762 per KW in 2020 to just over $1,000 by 2030 and $870 by 2040.

The estimated hard costs for the NCRS are higher than the NREL research but, importantly, include necessary microgrid components such as inverters, software, and other ancillary items. Moreover, it is assumed that a PPA provider's purchasing power would not rise to the level of large commercial installations, encouraging a more conservative analysis.

Interconnection fees are separately estimated based on very preliminary discussions with Eversource. It is important to note that this cost estimate may be subject to modification by the energy company based on the final system specifications and a more comprehensive review of capacities impacted by the microgrid development.

Future reinvestment costs are modeled at the end of the estimated useful life for each asset. They include an average year-over-year cost reduction of 3.0% and 3.5 % for solar PV and battery energy storage resources. Baseline inputs are as follows:

Solar Photovoltaic	$3,000/kW
Battery Energy Storage (4-hr rating)	$2,300/kW

Timing for the proposed improvements includes investment and operation commencing in 2022, with 30% of the operational capacity realized in 2022 (i.e., all DERs operating over approximately the last one-third of the year, considering the time of installation and interconnection process until the full capacity can function).

Total hard costs are estimated at $1.44 million, including installation cost, exclusive of a 30 % soft cost estimate and interconnection fees that increase estimated total capital expenditures to $1,97 million.

Table 23. Key Timing and Sizing Assumptions and Estimated Capital Costs

Timing Assumptions		WMS	SVTP	EGW	TF	BH	Total
Investment Year/Construction Start		2022	2022	2022	2022	2022	
First Operational Year		2022	2022	2022	2022	2022	
1st Year Operational Capacity %		30%	30%	30%	30%	30%	
Microgrid Capacity Inputs							
Solar PV	kW	275	54	-	-	18	347
Battery Output	KW	30	100	25	5	15	175
Battery Energy Storage (4-hr rating)	kWh	120	400	100	20	60	700
Capital Cost Estimate							
Solar PV		$825,000	$162,300	0	0	$54,000	$1,041,300
Battery Energy Storage (4-hr rating)		$69,000	$230,000	$57,500	$11,500	$34,500	$402,500
Interconnection Fees							$90,000
				Subtotal			$1,533,800
Project Overhead @30%							$433,140
Total Estimated Cost							$1,966,940

Source: Willdan, 2021

Other Battery-Related Sizing Considerations

The size relationship between the battery energy storage and solar photovoltaic resources, aside from the general energy strategy, has several financial implications that were considered and evaluated.

The Investment Tax Credit benefit is perhaps the most significant. It requires that the battery be charged at a minimum of 75% from renewable sources. The actual ITC benefit for a battery depends on the percent of the time the battery is charged by combined solar. Above 75%, the amount of the ITC is reduced to the actual percentage. For example, a system charged by renewable energy 80% of the time is eligible for the 30% ITC multiplied by 80%, which equals a 24% ITC instead of 30%[33]. Below 75%, the benefit is zero.

Similarly, this relationship impacts the Clean Peak Energy Credits calculation, which requires a 75% charging threshold from renewable sources to realize those benefits.

These relationships indicate diminishing financial benefits when the battery is oversized relative to its renewable charging source. Third-party owners will most likely seek to optimize this relationship to maximize the financial returns.

[33] https://www.nrel.gov/docs/fy18osti/70384.pdf

Specific to the recommended programs, the system elements and their relative sizes all possess the theoretical capacities to exceed 100% battery energy storage charging with Natick sites that have associated solar photovoltaic arrays . They would maximize the ITC benefit potential for owners that incur a federal tax liability.

5.7 Financial Analysis

The financial analysis is structured to profile the perspective of the Town of Natick entering into third-party owner/operator agreements for the microgrid improvements. This perspective is based on feedback and guidance from the Town after consideration of available financial resources, lack of capacity to operate and maintain the assets, and other related factors.

It is anticipated that the Town of Natick will execute Power Purchase Agreements (PPAs) for the solar PV assets and/or Energy Services Agreements (ESAs) for the battery energy storage assets. The estimated sources of financial inflows (revenues, tax credits, expense savings, etc.) and outflows (operational costs) are summarized in Table 30 and Table 31.

5.7.1 Key Assumptions

The following key assumptions underlie the financial analysis:

Inflation/Deflation: All estimates are presented in a constant value of 2021 dollars.

Solar PV Output: Energy output from the Natick's solar PV arrays is a function of both the relatively fixed engineering of the installed solar panel and the variability of sunlight, the latter dictated primarily by geographic location and orientation of the system to the sun. These variable elements are the primary definers for a location's "solar shape," data that is gathered from Folsom Lab's web-based subscription service Helioscope (www.helioscope.com). This service provides location-specific solar energy potentials across all 8,760 hours in a year at a given geographic location, enabling calculating total annual energy potential or more granular detail, such as output during defined peak hour periods.

Energy Resource Performance Degradation: Solar PV energy output and battery energy storage performance does not remain constant year over year. They slowly degrade with time, with batteries susceptible to higher levels of degradation with increased "cycling" or charging/discharging. Solar degradation is typically slower, constant, and more a function of wear and tear over time. For the financial analysis purposes, solar PV energy output and battery storage performance are modeled to degrade by 0.5% and 1.0% per year over their estimated useful life, respectively. These factors are both well within actual performance ranges.

Capital Reinvestment: Capital reinvestment is modeled at the end of each asset's useful life, with assumed annual reductions in pricing, as detailed in the capital investment section and summarized below.

	Est. Useful Life	CapEx Price Reduction per Yr.
Solar PV	25 yrs.	-3.0%
Battery Energy Storage (4-hr rating)	12 yrs.	-3.5%

Term: All financial estimates are modeled over a 20-year horizon.

5.8 Revenue and Other Financial Inflows

5.8.1 Investment Tax Credit

The value of the investment tax credit (ITC) is dependent on the timing of construction start, not operations. The ITC benefits are under constant evaluation and have been subject to prior extensions. Pending federal legislation could further adjust the percentage and/or timing of the ITC benefits. Considering this variability within a PPA or similar agreement may be warranted, as the value potential is substantial.

The current schedule for the ITC (based on construction start) is as follows:

Year	Commercial
2021	26%
2022	26%
2023	22%
2023+	10%

The financial model presented herein assumes that construction would commence before the end of 2022, creating a benefit for federal tax liable entities equal to 26% of project capital expenditures.

In addition, the energy output from the solar PV arrays in all energy resource locations exceeds 100% of co-located battery charging requirements, indicating the potential to maximize the battery ITC.

The value of the investment tax credit is estimated to total just over $486,000 in current value dollars. The early timing and cash flow are important investment considerations, as the amount exceeds the net operational proceeds ($274,000) generated in a stabilized year by the five Natick locations.

5.8.2 MA SMART Solar Program Incentive Payment

As described in the overview of the Commonwealth's SMART Solar Incentive Program in **Appendix A: Financial Analysis – Glossary of Terms**, the development of clean energy resources generates a substantial incentive opportunity for their owners. The NCRS was evaluated utilizing DOER's Value of Energy and Incentive Calculator. The calculator considers project type, size, distribution company service territory, customer rate class, and capacity block.

SMART incentive amounts for the NCRS resources range from $0.25 to over $0.31 per kWh of solar PV energy output.

The duration of the incentive is based on total capacity output, with those exceeding 25 KW AC provided a 20-year benefit, all others receiving a 10-year benefit.

Table 24. SMART Solar Incentive Rates

	WMS	SVTP	EGW	TF	BH
SMART Solar Base Generation Rate ($/kWh)	$0.17327	$0.20792	$0.18049	$0.18049	$0.27272
Location Adder ($/kWh)	$0.06000	$0.01920	$0.01920	$0.01920	$0.00000

Off-Taker Based ($/kWh)	$0.03064	$0.03064	$0.03064	$0.06000	$0.03064
Energy Storage Adder ($/kWh)	$0.04460	$0.04470	$0.04470	$0.04460	$0.04450
Total SMART Solar Payment ($/kWh)	$0.30851	$0.30246	$0.27503	$0.30429	$0.34786
SMART Duration of Benefits	20 Years	20 Years	20 Years	20 Years	10 Years

Source: MA SMART Solar Calculator and Willdan Financial Services, 2021

The total value of the SMART solar payment is estimated at just under $129,000 per year, calculated on the estimated annual solar at each location and totaling 417,000 kWh across the entire microgrid.

5.8.3 On-Bill Savings

On-bill savings are calculated utilizing Integral Analytics' *Site Optimizer*, a comprehensive DER sizing and support tool for integrating renewable energy investments.

Dollar value benefits are calculated by comparing the customer's current load profile against a solar load shape. This estimate utilizes the customer's current total electricity tariff (demand charge price, energy price, and basic meter charges), considering peak/off-peak hours and winter/summer seasonal pricing variations.

Battery benefits are isolated by calculating energy savings and demand charge reductions for the entire system, then subtracting the calculation for those benefits from solar alone. These cash values are then converted to a $/kWh value for calculation against the quantity of energy produced (solar PV) or energy stored (battery), capturing the degradation factor in the financial output.

Stabilized year estimates for on-bill savings total just under $88,000 annually. From a practical perspective, the solar PV array is the primary source of energy savings. At the same time, the battery is responsible for almost the entirety of demand charge savings, again highlighting the importance of this resource's ability to shift/lower demand during peak consumption periods.

5.8.4 PPA Solar PV Energy Payment from Host to Provider

Under the anticipated PPA structure, the Host/Town would likely be contractually obligated to purchase the energy produced by the solar PV array(s) from the PPA provider. A $0.125 per kWh was assumed to calculate this value, representing a discount of approximately $0.05 per kWh over the current average energy price for the microgrid sites. This equates to just under $189,000 paid to the provider in a typical year. A corresponding outflow, representing the Host/Town perspective, is detailed in the description of outflows later in this section of the report.

5.8.5 Demand Response (aka Connected Solutions)

Eversource Energy currently values demand response at $225 per kWh of battery capacity. This equates to an estimated annual value of $49,500 across the three NCRS sites based on recommended system parameters.

5.8.6 Clean Peak Energy Credits

The calculation of Clean Peak Energy Credits (CPECs) is based on program parameters that delineate "multipliers" for each megawatt of energy produced during certain defined periods during "normal" days and the "monthly peak" day.

Table 25. CPEC Seasonal and Time of Day Windows

Season Date and Times	Begin	End	Days in Season	Seasonal Peak Days	Monthly Peak Days	Peak Hours (between these values)		
Spring	1-Mar	14-May	75	73	2	5:00 PM	to	9:00 PM
Summer	15-May	14-Sep	123	119	4	3:00 PM	to	7:00 PM
Fall	15-Sep	30-Nov	77	74	3	4:00 PM	to	8:00 PM
Winter	1-Dec	28-Feb	90	87	3	4:00 PM	to	8:00 PM
			365	353	12			

Source: 225 CMR: MA Department of Energy Resources

The multipliers encourage participation by greatly increasing the quantity of CPECs and the economic value by increasing value when demand is highest. One additional positive multiplier is available for systems that enhance resiliency (1.5x), while others reduce the quantity of CPECs generated. This latter group includes resources already benefitting from SMART solar benefits (0.3x, applicable to the Solar PV arrays), the existing resource multiplier (0.1x), and the contracted resource multiplier (0.01x). These last two do not apply to the CPEC calculations for the NCRS.

Table 26. CPEC Multipliers

Day Type	Seasonal Day Type	Seasonal Multiplier	Monthly Peak Multiplier	Resilience Multiplier	Existing Resource Multiplier	Contracted Resource Multiplier	SMART ES Resource Multiplier
Normal Days	Spring Normal Day	1	1	1.5x	0.1x (Not applicable to this microgrid)	0.01x (Not applicable to this microgrid)	0.3x (Applicable only to solar PV energy)
	Summer Normal Day	4	1				
	Fall Normal Day	1	1				
	Winter Normal Day	4	1				
Monthly Peaks	Spring Peak Day	1	25				
	Summer Peak Day	4	25				
	Fall Peak Day	1	25				
	Winter Peak Day	4	25				

Source: 225 CMR: MA Department of Energy Resources

The NCRS is estimated to generate 474 CPECs annually, as presented in the table on the following page.

The market value of these CPECs is estimated at $21,300 at the current $45 Alternative Compliance Payment (ACP) [34]. The value of CPECs is estimated to decline, both as a factor of output degradation and the planned $1.54 annual reduction in the ACP commencing in 2025. This value may further shift (up or down) as the ACP price is adjusted through an annual review process and the number of CPECs issued. Oversupply relative to CPEC targets will generate small price decreases. Conversely, undersupply will raise the price, increasing the economic rationale for clean energy resource investment.

[34] https://www.mass.gov/service-details/annual-compliance-information-for-retail-electric-suppliers

Table 27. Estimated Clean Peak Energy Credits

		Solar PV			Battery Energy Storage			
		Peak Hour (kWh)	Daily CPECs	Annual CPECs	Discharge (kWh) [35]	Daily CPECs	Annual CPECs	Total CPECs
Normal Days	Spring Normal Day	97.9	0.0	3.2	595.0	0.2	16.1	19.3
	Summer Normal Day	434.3	0.8	93.0	595.0	0.9	105.2	198.2
	Fall Normal Day	71.1	0.0	2.4	595.0	0.2	16.3	18.7
	Winter Normal Day	57.3	0.1	9.0	595.0	0.9	76.9	85.8
Monthly Peaks	Spring Peak Day (2 days)	97.9	1.1	2.3	525.0	1.8	3.6	5.9
	Summer Peak Day (4 days)	434.3	20.3	81.3	525.0	7.3	29.1	110.4
	Fall Peak Day (3 days)	71.1	0.8	2.5	525.0	1.8	5.5	8.0
	Winter Peak Day (3 days)	57.3	2.7	8.0	525.0	7.3	21.8	29.9
						Grand Total		474

Source: Willdan Financial Services, 2021

5.8.7 Depreciation

Depreciation represents a significant source of value to the owners subject to federal income tax. As detailed in depreciation opportunities, the timing and selected depreciation methodology (Bonus vs. MCARS 5-year) can drive significant differences in value for the project.

For simplicity purposes and assuming an opportunity to claim 100% bonus depreciation (i.e., claimed in 2022), the difference in net present value when claiming the bonus versus spreading the benefit over five years generates an estimated net present value benefit of more than $22,800 (@ 8.25% discount rate).

5.9 Expenses and Other Outflows

5.9.1 Operations and Maintenance Expenses

Ongoing operations and maintenance expenses are estimated utilizing NREL research. Costs are estimated at $18 per KW for solar PV resources and $45 per KW for battery resources. Annual O&M expenses total just over $37,700 per year, with just under 85% attributed to the battery components.

5.9.2 Host Solar PV Energy Payment to PPA Provider

An ongoing, contractual cost of any PPA agreement is the commitment to purchase solar PV energy at a fixed annual rate. While the cost per kWh is anticipated to be a negotiated element of a PPA agreement, the financial model assumes an energy value of $0.125. This equates to an annual payment of just over

[35] Using battery for other avenue stream could impact the resiliency service negatively. The impact could be alleviated by close collaboration with location utility and emergency management department.

$52,200, based on nameplate capacity combined with historical solar radiation data in this area, by the Town/Host to the PPA provider.

5.9.3 Battery Round-Trip Energy Loss

Round-trip energy costs reflect the net expense of recharging a battery storage energy resource. The expense reflects that the energy needed to charge a battery is more than the amount of energy discharged. Round-trip efficiency is estimated at 80%. The loss value is equated using the average SMART solar rate across the entire project. The dollar value of this expense is estimated at just under $31,500 in a stabilized year.

5.10 Net Operating Revenues (Stabilized Operations)

Net operating revenue, exclusive of the ITC and depreciation benefits, is $236,700. This total includes $343,400 in operational inflows against $106,600 in direct operating expenses. This value excludes consideration of the timing of benefits. It represents a snapshot of performance based on the nameplate or theoretical capacities of the energy resources.

Table 28. Stabilized Year Statement

Microgrid Capacity Inputs	Accrues to:	Wilson MS	Springvale WP	Evergreen Wells	Town Forest	Broad Hill	Total
Solar PV (kW)		275	54	-	-	18	347
Battery Energy Storage (4-hr rating) (kWh)		120	400	100	20	60	700
Battery Power (KW)		30	100	25	5	15	175
Battery Power (MW)		0.03	0.10	0.03	0.01	0.02	0.18
Annual Solar Generation (kWh)		335,444	60,707	-	-	21,644	417,795
Initial Capital Investment							
Solar PV	Provider	$ 825,000	$ 162,300	$ -	$ -	$ 54,000	$ 1,041,300
Battery Energy Storage (4-hr rating)	Provider	69,000	230,000	57,500	11,500	34,500	402,500
Interconnection & Infrastructure Upgrades	Provider	55,728	24,454	3,584	717	5,517	90,000
Project Administration/Overhead (30% of hard costs)	Provider	268,200	117,690	17,250	3,450	26,550	433,140
Total Initial Capital Investment		**$ 1,217,928**	**$ 534,444**	**$ 78,334**	**$ 15,667**	**$ 120,567**	**$ 1,966,940**
Operating Inflows	**Accrues to:**						
MA SMART Solar Program Incentive Payment 3/	Provider	103,488	18,362	-	-	7,529	129,378
On-Bill Savings - Demand Charge	Split	18,559	27,155	-	-	-	45,714
On-Bill Savings - Energy Charge	Host	32,262	5,848	4	1	4,166	42,281
PPA Solar PV Energy Payment from Host to Provider 4/	Provider	41,930	7,588	-	-	2,706	52,224
Demand Response aka Connected Solutions	Split	9,000	30,000	7,500	1,500	4,500	52,500
Clean Energy Peak Credit-Solar PV	Split	7,555	1,123	-	-	399	9,077
Clean Energy Peak Credit-Battery Storage	Split	2,105	7,018	1,754	351	1,053	12,281
Total Operating Inflows		**$ 214,900**	**$ 97,093**	**$ 9,258**	**$ 1,852**	**$ 20,353**	**$ 343,456**
Operating Outflows	**Accrues to:**						
Operations & Maintenance Expenses							
Solar PV	Provider	$ 4,950	$ 974	$ -	$ -	$ 324	$ 6,248
Battery Energy Storage (4-hr rating)	Provider	5,400	18,000	4,500	900	2,700	31,500
Total Operations and Maintenance		$ 10,350	$ 18,974	$ 4,500	$ 900	$ 3,024	37,748
Host Solar PV Energy Payment to PPA Provider 4/	Host	$ 41,930	$ 7,588	$ -	$ -	$ 2,706	52,224
Battery Round Trip Energy Loss	Split	$ 2,863	$ 9,544	$ 2,386	$ 477	$ 1,432	16,702
Total Operating Outflows		**$ 55,144**	**$ 36,106**	**$ 6,886**	**$ 1,377**	**$ 7,161**	**$ 106,675**
Net Operating Cash Flow		**$ 159,757**	**$ 60,987**	**$ 2,372**	**$ 475**	**$ 13,192**	**$ 236,781**
Investment Tax Credit							
Solar PV Investment Tax Credit (ITC) 1/	Provider	$ 292,221	$ 57,488	$ -	$ -	$ 19,127	$ 368,836
Battery Storage Investment Tax Credit (ITC) 1/ 2/	Provider	24,440	81,468	-	-	12,220	118,128
Total ITC		$ 316,661	$ 138,955	$ -	$ -	$ 31,347	$ 486,964
Depreciation 5/							
Bonus Depreciation Percentage		100%	100%	100%	100%	100%	
Bonus Depreciation Taxable Basis		735,669	322,822	57,500	11,500	72,826	1,200,318
MACRS Taxable Basis 6/	Provider	-	-	-	-	-	-
Depreciation Benefit @ 22% Federal Tax Rate	Provider	161,847	71,021	12,650	2,530	16,022	264,070
Net Cash Flow after ITC and Depreciation		**$ 638,265**	**$ 270,963**	**$ 15,022**	**$ 3,005**	**$ 60,561**	**$ 987,815**

1/ Investment Tax Credit percent is 26.0% if construction commences in 2021 or 2022, 22.0% in 2023, and 10.0% thereafter.
2/ Battery must receive a minimum of 75% of charging over the entire year from renewable sources; tax credit is then proportioned by the percentage of power 75% or higher.
3/ MA Smart Program Incentive duration is 10 years for systems ≤ 25 kW AC or 20 years for systems >25 kW AC.
4/ PPA Energy Payment $0.125 per kWh
5/ Bonus depreciation capture requires all assets be depreciated under this methodology; if bonus amount is less than 100 percent, any remainder is depreciated under MACRS schedule.
6/ MACRS depreciation schedule is variable year-to-year; this basis (less one-half of the federal ITC) is calculated using the annual average of 16.67 percent.
7/ Model assumes zero ($0) residual value of assets at end of useful life
Source: Willdan Financial Services, 2021

5.11 Multi-Year Financial Analysis

The multi-year presentation of estimated cash flows presents a clearer understanding of the benefits over time. It allows for incorporating the important ITC and depreciation tax advantages that comprise significant elements of overall project value over a 20-year term.

Moreover, the analysis provides an opportunity to segregate estimated revenues and expenses to the Town/Host, PPA provider, or split the values between the parties and then evaluate the relative position from a total cash flow and discounted cash flow perspective. Lastly, the model provides the opportunity to test variables and modify assumptions to understand the relative position of each party and identify terms that could be negotiated that would continue to provide adequate (although lower than targeted) returns to a PPA provider.

As noted earlier, ITC and depreciation benefits have specific time parameters. These values are modeled to achieve their maximum potential. This requires commencement of construction in 2022, providing the full ITC benefit and capture of 100% bonus depreciation by the PPA Provider.

The assumed allocation of the remaining inflows and outflows is presented below.

Table 29. Summary of Allocation Assumptions

Category	Accrues to:
Initial Capital Investment	
Solar PV	Provider
Battery Energy Storage (4-hr rating)	Provider
Interconnection & Infrastructure Upgrades	Provider
Project Administration/Overhead (30% of hard costs)	Provider
Operating Inflows	
MA SMART Solar Program Incentive Payment	Provider
On-Bill Savings - Demand Charge	Split
On-Bill Savings - Energy Charge	Host
PPA Solar PV Energy Payment from Host to Provider	Provider
Demand Response	Split
Clean Energy Peak Credit-Solar PV	Split
Clean Energy Peak Credit-Battery Storage	Split
Operating Outflows	
Operations & Maintenance Expenses	Provider
Host Solar PV Energy Payment to PPA Provider	Host
Battery Round Trip Energy Loss	Split
Investment Tax Credit	Provider
Depreciation	Provider

Source: Willdan Financial Services, 2021

Split items within the financial analysis are assumed to allocatee 60% to the PPA provider and 40% to the Town/Host based on negotiation.

Multi-year net cash flows are somewhat lower than the stabilized year figure, reflecting the effects of battery storage and solar PV performance degradation. The estimated net cash flow totals $232,000 in the first full year, decreasing to $202,000 in the last full year (constant value 2021 dollars).

The following assumptions support the cash flow analysis detailed in Table 30:

1. Investment Tax Credit percent is 26.0% if construction commences in 2021 or 2022, 22.0% in 2023, and 10.0% thereafter.
2. A battery must receive a minimum of 75% of charging over the entire year from renewable sources; tax credit is then proportioned by the percentage of power 75% or higher.
3. MA Smart Program Incentive duration is ten years for systems ≤ 25 kW AC or 20 years for systems >25 kW AC.
4. PPA Energy Payment assumes $0.125 per kWh.
5. Bonus depreciation capture requires all assets to be depreciated under this methodology; if the bonus amount is less than 100%, any remainder is depreciated under the MCARS schedule.
6. The model assumes zero ($0) residual value of assets at the end of useful life

Table 30. Statement of Estimated 20-Year Cash Flow

Total Capital Investment: Years 1-10	**Accrues to:**	**Yr1 2022**	**Yr2 2023**	**Yr3 2024**	**Yr4 2025**	**Yr5 2026**	**Yr6 2027**	**Yr7 2028**	**Yr8 2029**	**Yr9 2030**	**Yr10 2031**
Effective Capacities/Outputs (assumes degradation over time)											
Solar PV (kW)		104	345	344	342	340	339	337	335	333	332
Battery Energy Storage (4-hr rating) (kWh)		210	693	686	679	672	666	659	652	646	639
Battery Power (KW)		53	173	172	170	168	166	165	163	161	160
Battery Power (MW)		0.05	0.17	0.17	0.17	0.17	0.17	0.16	0.16	0.16	0.16
Annual Solar Generation (kWh)		125,338	415,706	413,627	411,559	409,502	407,454	405,417	403,390	401,373	399,366
% of Initial Battery Storage Capacity		30.0%	99.0%	98.0%	97.0%	96.1%	95.1%	94.1%	93.2%	92.3%	91.4%
% of Initial Solar PV Output		30.0%	99.5%	99.0%	98.5%	98.0%	97.5%	97.0%	96.6%	96.1%	95.6%
Initial Capital Investment											
Solar PV	Provider	1,010,061	-	-	-	-	-	-	-	-	-
Battery Energy Storage (4-hr rating)	Provider	388,413	-	-	-	-	-	-	-	-	-
Interconnection & Infrastructure Upgrades	Provider	90,000	-	-	-	-	-	-	-	-	-
Project Administration/Overhead (30% of hard costs)	Provider	419,542	-	-	-	-	-	-	-	-	-
Total Initial Capital Investment		$1,908,016	$-	$-	$-	$-	$-	$-	$-	$-	$-
Capital Reinvestment											
Solar PV	Provider	-	-	-	-	-	-	-	-	-	-
Battery Energy Storage (4-hr rating)	Provider	-	-	-	-	-	-	-	-	-	-
Project Administration/Overhead (30% of hard costs)	Provider	-	-	-	-	-	-	-	-	-	-
Total Reinvestment		$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
Total Capital Investment		$1,908,016	$-	$-	$-	$-	$-	$-	$-	$-	$-

Note: Yr1 and Yr21 are partial years
Source: Town of Natick; Willdan, 2022

Table 30: Statement of Estimated 20-Year Cash Flow, Continued

Total Capital Investment: Years 11-21	Accrues to:	Yr11 2032	Yr12 2033	Yr13 2034	Yr14 2035	Yr15 2036	Yr16 2037	Yr17 2038	Yr18 2039	Yr19 2040	Yr20 2041	Yr21 2042
Effective Capacities/Outputs (assumes degradation over time)												
Solar PV (kW)		330	328	327	325	324	322	320	319	317	316	314
Battery Energy Storage (4-hr rating) (kWh)		633	627	700	693	686	679	672	666	659	652	646
Battery Power (KW)		158	157	175	173	172	170	168	166	165	163	161
Battery Power (MW)		0.16	0.16	0.18	0.17	0.17	0.17	0.17	0.17	0.16	0.16	0.16
Annual Solar Generation (kWh)		397,369	395,382	393,405	391,438	389,481	387,534	385,596	383,668	381,750	379,841	377,942
% of Initial Battery Storage Capacity		90.4%	89.5%	100.0%	99.0%	98.0%	97.0%	96.1%	95.1%	94.1%	93.2%	92.3%
% of Initial Solar PV Output		95.1%	94.6%	94.2%	93.7%	93.2%	92.8%	92.3%	91.8%	91.4%	90.9%	90.5%
Initial Capital Investment												
Solar PV	Provider	-	-	-	-	-	-	-	-	-	-	-
Battery Energy Storage (4-hr rating)	Provider	-	-	-	-	-	-	-	-	-	-	-
Interconnection & Infrastructure Upgrades	Provider	-	-	-	-	-	-	-	-	-	-	-
Project Administration/Overhead (30% of hard costs)	Provider	-	-	-	-	-	-	-	-	-	-	-
Total Initial Capital Investment		$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
Capital Reinvestment												
Solar PV	Provider	-	-	-	-	-	-	-	-	-	-	-
Battery Energy Storage (4-hr rating)	Provider	-	-	253,292	-	-	-	-	-	-	-	-
Project Administration/Overhead (30% of hard costs)	Provider	-	-	75,988	-	-	-	-	-	-	-	-
Total Reinvestment		$-	$-	$329,279	$-	$-	$-	$-	$-	$-	$-	$-
Total Capital Investment		$-	$-	$329,279	$-	$-	$-	$-	$-	$-	$-	$-

Note: Yr1 and Yr21 are partial years
Source: Town of Natick; Willdan, 2022

Table 30: Statement of Estimated 20-Year Cash Flow, Continued

Net Cash Flow after ITC & Depreciation: Years 1-10	**Accrues to:**	**Yr1 2022**	**Yr2 2023**	**Yr3 2024**	**Yr4 2025**	**Yr5 2026**	**Yr6 2027**	**Yr7 2028**	**Yr8 2029**	**Yr9 2030**	**Yr10 2031**
Operating Inflows											
MA SMART Solar Program Incentive Payment 3/	Provider	38,814	128,731	128,088	127,447	126,810	126,176	125,545	124,917	124,293	123,671
On-Bill Savings - Demand Charge	Split	13,714	45,323	44,936	44,552	44,171	43,794	43,421	43,051	42,684	42,321
On-Bill Savings - Energy Charge	Host	12,684	42,069	41,859	41,649	41,441	41,234	41,027	40,822	40,618	40,415
PPA Solar PV Energy Payment from Host to Provider 4/	Provider	15,667	51,963	51,703	51,445	51,188	50,932	50,677	50,424	50,172	49,921
Demand Response aka Connected Solutions	Split	15,750	51,975	51,455	50,941	50,431	49,927	49,428	48,933	48,444	47,960
Clean Energy Peak Credit-Solar PV	Split	2,723	9,032	8,987	8,636	8,288	7,944	7,602	7,265	6,930	6,598
Clean Energy Peak Credit-Battery Storage	Split	`	12,158	12,037	11,508	10,990	10,480	9,980	9,488	9,005	8,531
Total Operating Inflows		$99,352	$341,252	$339,064	$336,178	$333,319	$330,487	$327,680	$324,900	$322,146	$319,417
Operating Outflows	Accrues to:										
Operations & Maintenance Expenses											
Solar PV	Provider	1,874	6,217	6,185	6,155	6,124	6,093	6,063	6,032	6,002	5,972
Battery Energy Storage (4-hr rating)	Provider	9,450	31,185	30,873	30,564	30,259	29,956	29,657	29,360	29,066	28,776
Total Operations and Maintenance		$11,324	$37,402	$37,059	$36,719	$36,383	$36,049	$35,719	$35,392	$35,069	$34,748
Host Solar PV Energy Payment to PPA Provider 4/	Host	$15,667	$51,963	$51,703	$51,445	$51,188	$50,932	$50,677	$50,424	$50,172	$49,921
Battery Round Trip Energy Loss	Split	$5,996	$19,821	$19,656	$19,492	$19,329	$19,169	$19,009	$18,851	$18,695	$18,540
Total Operating Outflows		$32,988	$109,186	$108,418	$107,656	$106,900	$106,150	$105,406	$104,667	$103,935	$103,208
Net Operating Cash Flow		$66,365	$232,066	$230,647	$228,523	$226,419	$224,337	$222,275	$220,233	$218,211	$216,209
Investment Tax Credit	Accrues to:										
Solar PV Investment Tax Credit (ITC) 1/	Provider	$357,771	$-	$-	$-	$-	$-	$-	$-	$-	$-
Battery Storage Investment Tax Credit (ITC) 1/ 2/	Provider	137,579	-	-	-	-	-	-	-	-	-
Total ITC		$495,349	$-	$-	$-	$-	$-	$-	$-	$-	$-
Depreciation 5/	Accrues to:										
Bonus Depreciation Taxable Basis		1,188,098	-	-	-	-	-	-	-	-	-
Modified Accelerated Cost Recovery System (MACRS) Taxable Basis		-	-	-	-	-	-	-	-	-	-
Depreciation Benefit @ 22% Federal Tax Rate	Provider	261,382	-	-	-	-	-	-	-	-	-
Net Cash Flow after ITC and Depreciation		$327,746	$232,066	$230,647	$228,523	$226,419	$224,337	$222,275	$220,233	$218,211	$216,209

Source: Town of Natick; Willdan, 2022

Table 30. Statement of Estimated 20-Year Cash Flow, Continued

Net Cash Flow after ITC & Depreciation: Years 11-20	**Accrues to:**	**Yr11 2032**	**Yr12 2033**	**Yr13 2034**	**Yr14 2035**	**Yr15 2036**	**Yr16 2037**	**Yr17 2038**	**Yr18 2039**	**Yr19 2040**	**Yr20 2041**	**Yr21 2042**
Operating Inflows												
MA SMART Solar Program Incentive Payment 3/	Provider	115,892	115,313	114,736	114,162	113,592	113,024	112,458	111,896	111,337	110,780	-
On-Bill Savings - Demand Charge	Split	41,961	41,604	44,943	44,555	44,172	43,792	43,415	43,042	42,672	42,306	41,943
On-Bill Savings - Energy Charge	Host	40,213	40,012	39,814	39,614	39,416	39,219	39,023	38,828	38,633	38,440	38,248
PPA Solar PV Energy Payment from Host to Provider 4/	Provider	49,671	49,423	49,176	48,930	48,685	48,442	48,199	47,958	47,719	47,480	47,243
Demand Response aka Connected Solutions	Split	47,480	47,005	52,500	51,975	51,455	50,941	50,431	49,927	49,428	48,933	48,444
Clean Energy Peak Credit-Solar PV	Split	6,270	5,944	5,622	5,303	4,987	4,674	4,364	4,057	3,753	3,451	3,153
Clean Energy Peak Credit-Battery Storage	Split	8,066	7,609	8,078	7,581	7,094	6,615	6,145	5,684	5,231	4,787	4,352
Total Operating Inflows		**$309,552**	**$306,910**	**$314,868**	**$312,121**	**$309,400**	**$306,705**	**$304,036**	**$301,392**	**$298,773**	**$296,178**	**$183,382**
Operating Outflows	Accrues to:											
Operations & Maintenance Expenses												
Solar PV	Provider	5,942	5,913	5,883	5,854	5,824	5,795	5,766	5,737	5,709	5,680	5,652
Battery Energy Storage (4-hr rating)	Provider	28,488	28,203	31,500	31,185	30,873	30,564	30,259	29,956	29,657	29,360	29,066
Total Operations and Maintenance		$34,430	$34,116	$37,383	$37,039	$36,698	$36,360	$36,025	$35,694	$35,365	$35,040	$34,718
Host Solar PV Energy Payment to PPA Provider 4/	Host	$49,671	$49,423	$49,176	$48,930	$48,685	$48,442	$48,199	$47,958	$47,719	$47,480	$47,243
Battery Round Trip Energy Loss	Split	$18,386	$18,234	$19,601	$19,436	$19,273	$19,111	$18,950	$18,791	$18,634	$18,478	$18,323
Total Operating Outflows		**$102,487**	**$101,772**	**$106,159**	**$105,404**	**$104,655**	**$103,912**	**$103,175**	**$102,444**	**$101,718**	**$100,998**	**$100,284**
Net Operating Cash Flow		**$207,065**	**$205,137**	**$208,709**	**$206,717**	**$204,745**	**$202,793**	**$200,861**	**$198,948**	**$197,055**	**$195,180**	**$83,098**
Investment Tax Credit	Accrues to:											
Solar PV Investment Tax Credit (ITC) 1/	Provider	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
Battery Storage Investment Tax Credit (ITC) 1/ 2/	Provider	-	-	-	-	-	-	-	-	-	-	-
Total ITC		$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
Depreciation 5/	Accrues to:											
Bonus Depreciation Taxable Basis		-	-	-	-	-	-	-	-	-	-	-
Modified Accelerated Cost Recovery System (MACRS) Taxable Basis			-	-	-	-	-	-	-	-	-	-
Depreciation Benefit @ 22% Federal Tax Rate	Provider	-	-	-	-	-	-	-	-	-	-	-
Net Cash Flow after ITC and Depreciation		**$207,065**	**$205,137**	**$208,709**	**$206,717**	**$204,745**	**$202,793**	**$200,861**	**$198,948**	**$197,055**	**$195,180**	**$83,098**

Note: Yr1 and Yr21 are partial years
Source: Town of Natick; Willdan, 2022

Table 31. 20-Year Cash Flow & Investment Deal Structuring

Financial Summary & Investment Analytics	Yr1 2022	Yr2 2023	Yr3 2024	Yr4 2025	Yr5 2026	Yr10 2031	Yr15 2036	Yr20 2041
Estimated Cash Flows								
Total Provider Inflows	$830,524	$251,788	$250,240	$248,274	$246,326	$236,838	$226,901	$217,947
Total Provider Outflows[1]	(1,922,938)	(49,294)	(48,852)	(48,414)	(47,980)	(45,872)	(48,261)	(46,127)
Net Provider Cash Flow	$(1,092,413)	$202,494	$201,388	$199,860	$198,346	$190,966	$178,640	$171,820
Cumulative Provider Cash Flow ($millions)	$(1.09)	$(0.89)	$(0.69)	$(0.49)	$(0.29)	$0.68	$1.25	$78,231
								(54,871)
Provider's Total Cumulative 20-Yr Cash Flow	$2,186,221							
NPV of Provider's Estimated 20-Yr Cash Flow @ 8.25% Discount Rate	$2,271,827		$507,185					
IRR of Provider's Estimated 20-Yr Cash Flow	15.9%							
First Year of Positive Cumulative Cash Flow	Year 7							
Total Host/Town Inflows	$25,559	$89,464	$88,824	$87,904	$86,993	$82,579	$82,499	$ 78,231
Total Host/Town Outflows	(18,066)	(59,892)	(59,566)	(59,242)	(58,919)	(57,337)	(56,394)	(54,871)
Net Host/Town Cash Flow	$7,493	$29,573	$29,259	$28,662	$28,074	$25,242	$26,105	**$ 23,360**
Cumulative Host/Town Cash Flow ($thousands)	$7,493.36	$37	$66	$95	$123	$254	$384	**$506**
Host's Total Cumulative 20-Yr Cash Flow	$528,806							
NPV of Host's 20-Yr Estimated Cash Flow @ 3.00% Discount Rate	$376,539							

[1] Assumes Provider reinvests total value of initial capital in Year 14 at the end of equipment's estimated useful life.
Source: Town of Natick; Willdan, 2022

5.12 Financial Analysis Conclusions

The allocations of inflows and outflows indicate strong financial positions for both the PPA provider and the Town/Host. The PPA provider's internal rate of return (assuming an all-cash deal) equates to 15.9% and a net present value of $507,000, calculated using a discount rate of 8.25%.

The Town's cash flow over the 20-year term is estimated at $1.1 million, generating a net present value of $529,000 when discounted at a rate of 3.0% annually. This discount rate reflects the relatively lower cost of capital typically available to a public entity.

5.13 Financial Sensitivity Analysis

What represents an acceptable rate of return to either party in a PPA deal is difficult to isolate, as those involved measure and value motivations and risks differently. This question is the basis for negotiation. Yet to negotiate effectively, it is helpful to understand the various drivers that can be modified and their impact on financial returns.

The financial analysis is based on the primary objective to solve for a PPA provider return of 12%, a purely theoretical assumption for planning purposes only. It is unlikely that any negotiation would focus on just a single assumption but on a combination of adjustments that identify mutually beneficial returns and other benefits to each party. The following table provides the results of financial sensitivity analyses of the impact of a broad range of variables on the relative negotiation position of each party.

Variable	Financial Feasibility Impact
Capital Costs	Capital expenditures could increase by 49%
Split to Town:	The allocation of "split" revenue and expense items could increase to 100% to the Town/host versus the modeled 40%, generating an estimated internal rate of return of 15.9% to the provider.
PPA Energy Price:	PPA energy price could decrease to -$0.008 per kWh (indicating payment to the host), highlighting the relatively substantial benefits of the SMART Solar Program and federal tax incentives
Battery Useful Live	Battery useful life is estimated at 12 years, requiring one reinvestment cycle over the 20-year term that is modeled to accrue to the PPA provider. Reduction of the useful life to 10 years and the addition of a second replacement cycle at the end of the 20-year term would reduce the provider's estimated internal rate of return by 0.2%, to 15.66 %.

Importantly, future expansion or modification of existing programs, new incentives, grants, and other financial enhancements are possible but not modeled. Preservation of rights to these benefits, carbon credits, and other efforts to monetize environmental benefits may be additional points of consideration and sources of negotiation.

6. Conclusion

The Town of Natick's CLEAR study demonstrates both technical and financial options to solve threats to the municipal assets in the community. The threats to the infrastructure are both climate change and human-created disasters. Energy is essential to municipal operations and basic constituent services.

Resilient solutions are needed to carry the Town of Natick through interruptions to the power grid in the region.

Based on these key investment and operating parameters, the current annual energy costs and CO_2 emissions for the existing loads were calculated to be $428,000 and 728 metric tons. This represents the baseline for the proposed clean resiliency solution. The proposed solution would have 24.9% annual cost savings compared to the base case and a 12.2% annual reduction in CO_2 emissions. The annual CO_2 emission reduction is 89 metric tons. The resiliency-oriented solution could provide unlimited islanding capacity for BH and up to weeks for WMS in normal weather conditions, around 10 hours for SVTP, EW, and TF due to either limited or unavailable solar installation space.

An owner must have a tax liability to utilize federal/state tax incentives such as ITCs on the proposed solar and battery storage installations. The proposed clean resiliency solution could be owned jointly by the stakeholders, a third-party investor, or partly owned by a public utility (e.g., battery storage).

Since most stakeholders are public, a third-party special-purpose entity (NRCS Co.) will likely be developed to own and manage the DER mix. The participants would subsequently draft and enter into long-term agreements (the Power Purchase Agreement) to purchase energy from the DER owner/operator.

The financial analysis assumes a third-party PPA funding model. The PPA provider would build and maintain the new generation assets and the clean resiliency solution.

The financial analysis and allocations of Town (Host)/PPA inflows and outflows indicate strong financial positions for both the PPA provider and the Town (Host).

The PPA provider's internal rate of return (assuming an all-cash deal) equates to 15.9% and a net present value of $507,000, calculated using a discount rate of 8.25%.

The Town's cash flow over the 20-year term is estimated at $528,000, generating a net present value of $376,000 when discounted at a rate of 3.0% annually.

The Town of Natick can demonstrate a working clean, resiliency community in Massachusetts.

Appendix A: Financial Analysis – Glossary of Terms

The following key terms (and their acronyms) are defined to inform audiences with limited technical training related to the development of microgrids and their component distributed energy sources (DERS).

Battery Storage

Battery technology is rapidly changing and evolving. Currently, two technologies are poised to dominate the near-term landscape for large-scale commercial applications: Lithium-ion (Li-ion) and Vanadium (V-flow). Older technologies, such as lead/acid (car battery), and nickel/cadmium or NiCad (laptops and camcorders), have either been displaced from or are not viable for commercial storage applications.

One of the key attributes of batteries, aside from basic storage/use, is the ability to displace consumption of high cost/peak demand energy (peak shaving) with energy stored from renewable sources (best) or grid energy produced during lower cost/demand periods during the day or night (better). Another benefit is the instantaneous responsiveness of batteries to support energy needs, either locally or within the broader electrical grid.

Battery lifetimes typically range from 5 to 15 years. Warranties and lifetimes are typically tied to a specific number of recharging cycles or when a battery will only charge to 70 percent of the original nameplate capacity. Battery capacity also degrades over time, with storage losses of typically between one-half (0.5%) and two percent (2.0%) per year.

Capital planning must consider battery replacement costs for longer-term projects, especially if the functional lifetime is closer to 10 years than 15. The good news here is that the future cost to replace may be lower for the same quantity of energy storage. Pricing per kWh of storage has decreased at an average rate of eight (8) percent over the past several years. Forward-looking estimates anticipate annual price reductions ranging between 2.5 percent and 9.2 percent per kW through 2030, and smaller but continuous annual reductions through 2050 (1.3%-2.7%).

Improved design and increased manufacturing capacity, competition and innovation are the primary forces driving lower prices. For illustrative purposes, a $100 battery today could cost less than $50 in 15 years (current year dollars), assuming a five percent (5.0%) average annual price decrease.

Black Start Support

A black start is the process of restoring an electric power station or a part of an electric grid to operation without relying on the high-cost external electric power transmission network to recover from a total or partial shutdown. When available, hydroelectric power sources represent an excellent source of black start capacity due to the low power requirements to bring that asset online, which through a series of steps, can then restart the other power plants in the system. Stored battery power is similarly poised to serve in this capacity, requiring no “startup” and instantaneous responsiveness potential.

Clean Peak Energy Credits (CPEC)

The Clean Peak Standard (CPS) is designed to provide incentives to clean energy technologies that can supply electricity or reduce demand during seasonal peak demand periods established by DOER.

Under the program, all retail electric suppliers in Massachusetts are required to procure a minimum percentage of total annual electricity sales to Massachusetts end-use customers from Clean Peak Resources by either purchasing CPECs or retiring earned CPECs. Starting at 1.5% of retail electricity sales in 2020, the minimum requirement increases over time by at least 1.5% each year, to a target of 16.5% in 2030 and 46.5% in 2050. The program will expire in 2050, unless extended by law.

The value of a CPEC is set annually, based on the total megawatts (MW) of energy produced by qualified units. As of January 2021, the Commonwealth identified 17 qualified resources generating just under 37 MW of energy (nameplate capacity). DOER utilizes monthly reported peak to identify when the Actual Monthly System Peak Multiplier should adjust the number of Clean Peak Energy Certificates.

The value of each CPEC, while variable, is effectively capped by a provision that allows the retail electric supplier to satisfy their Clean Peak Standard's minimum requirement via an alternative compliance payment ("ACP").

The initial ACP rate is $45.00 per MWh through the 2024 compliance year. Thereafter, it is programmed to decline by $1.54 per MWh each year through 2050. Adjustments to the automatic ACP reduction are tied to the market supply of CPECs. If the supply is greater than the targeted level during the program year, the ACP rate reduction would be larger in the following year.

Demand Response (Active and Passive)

There are two types of demand response resources: active and passive, each with its own revenue implications.

Active demand resources comprise what is commonly referred to as Demand Response (DR). ISO-NE has two branded programs – Daily Dispatch and Connected Solutions. These programs both provide payments for being on [active] stand-by to be "called" to lower energy usage when the power grid is anticipated to be stressed or when the risk of failure is too high. This could include customers powering down equipment or switching to an alternative energy source, such as a generator or battery storage. Participants typically receive one-day notification for events that occur most often in July and August for events that last two to three hours.

Under the "active" DR Program, assets under 5 MW are consolidated or "mapped" into larger blocks referred to as Demand-Response Resources. Assets over 5MW comprise their own resource. These "resources" are then the direct participants in the DR program that comprise a small portion of the ISO's overall supply obligations. The market price for active DR varies by location and seasonally. Demand response was valued by Eversource at $200 per kW in the New England market for summer 2020.

Summer peak hours are non-holiday weekdays, 1:00 p.m. to 5:00 p.m., June, July, and August. Winter peak hours are non-holiday weekdays, 5:00 p.m. to 7:00 p.m., December and January. Participation can be limited to the summer months only. Benefits would be reduced by two-thirds under this option.

Seasonal-peak resources provide the same attributes as on-peak resources, but only during the summer months of June, July, and August, and the winter months of December and January, during those hours on non-holiday weekdays when the real-time system hourly load is equal to or greater than 90 percent of the system peak-load "50/50" forecast (50% chance of exceeding the calculated peak load for a New England-wide summer temperature of 90.2°F, and winter temperature of 7.0°F).

Passive demand resources (DR-P) are principally designed to save electricity and cannot be altered or "called" by a dispatch instruction. Examples include energy-efficient appliances and lighting, advanced cooling and heating technologies, and passive behind-the-meter generation, such as solar power. Passive demand resources can only participate in the On-Peak or Seasonal-Peak capacity markets.

Consolidated Heat and Power (CHP)

Consolidated Heat and Power, or cogeneration, is the concurrent production of electricity or mechanical power and the capture of by-product thermal energy from a single source of energy, typically near a point of consumption. CHPs can use a variety of fuels, both fossil- and renewable-based and a variety of technologies (gas turbines, microturbines, reciprocating engines, steam turbines, absorption chillers, and fuel cells). Generally, CHPs deliver energy at an efficiency of 65-75 percent versus a national average of 50 percent when the services are provided separately.

Curtailment Service Providers (CSP)

Curtailment Service Providers are organizations that, through a contractual arrangement, manage Demand Response (DR) programs. Commonly referred to as aggregators, these independent firms market DR opportunities, size the DR opportunity, manage curtailment events/communications, and calculate payments and underperformance penalties. The fee for this service typically ranges between 20 and 40 percent of the benefit amount.

Curtailment

Curtailment is the deliberate reduction in output (below what could have been produced) to address the interconnected issues of oversupply, reliability issues arising from excess energy production, and market pressure to lower pricing, in some instances to negative values.
While several types of curtailment exist, "economic dispatch" (due to low market price) is by far the most common. It is a self-scheduled response to a call for less generation for a fee.

Depreciation

Depreciation is an accounting reduction in the value of an asset with the passage of time. In the simplest application, depreciation would reflect wear and tear and an asset's useful life. Internal Revenue Service (IRS) rules establish rules for the capture of depreciation, at times setting asset schedules that do not align with the anticipated useful lifetime, primarily as an investment incentive. These accelerated schedules increase the capture of depreciation early in the investment horizon, providing a source of savings on federal income taxes. The amount of tax savings, however, is dependent on the effective federal tax rate of the ownership entity.

Under the Investment Tax Credit (see ITC) legislation, two methodologies for depreciation are available: Bonus and Modified Accelerated Cost Recovery System (MCARS).

Under the Bonus depreciation schedule, solar systems placed in service between January 1, 2018, and December 31, 2022, can elect to claim a 100% bonus depreciation of capital equipment in that tax year. Starting in 2023, the percentage drops 20% per year (e.g., 80% in 2023 and 60% in 2024) until the provision drops to 0% in 2027. If the ITC is claimed, the depreciable basis of the asset(s) is decreased by one-half of the ITC amount received (see ITC).

Important considerations when selecting the bonus depreciation methodology are rules requiring that all assets must be placed in the bonus depreciation pool and that assets must be owned for at least six years to fully vest the benefits. If the assets are not held for the duration, the paid tax benefits would be subject to recapture.

Alternatively, under the MCARS methodology, solar PV with associated battery storage could be depreciated under the 5-year Property, Half-Year Convention schedule. The annual amount of capital investment calculated for depreciation would follow this schedule:

Year	Value of CapEx Depreciation
Year 1	20.00%
Year 2	32.00%
Year 3	19.20%
Year 4	11.52%
Year 5	11.52%
Year 6	5.76%

Source: U.S. Department of Energy; Willdan, 2021

This schedule would also apply to any amount not captured by the bonus depreciation (i.e., if 60 percent taken under the bonus rules, then remaining 40 percent could use the MCARS methodology). As with the bonus depreciation option, the actual benefit would equate to the depreciable amount times the effective corporate tax rate.

Solar PV, without the associated battery component, would be subject to a 7-year depreciation schedule. Current full text documentation can be found at: https://www.energy.gov/eere/solar/articles/residential-and-commercial-itc-factsheets.

Distributed Energy Resource (DER)

Distributed energy resources are the physical and virtual energy assets that are deployed across a distribution network and comprise a microgrid. Physical assets typically include solar PV, battery storage, and less frequently consolidated heat and power and wind turbines. Inclusive in this definition is the technology that connects the assets to the bulk energy system (typically referred to as the “electric grid”) and the controls that allow for participation in secondary energy market opportunities (e.g., demand response, peak shaving)

Forward Capacity Market (FCM) Savings

The Forward Capacity Market (formerly referred to as the Installed Capacity Market) is a long-term wholesale electricity market that ensures resource adequacy, locally and systemwide, through an auction process that typically runs three years prior to the commitment year. This longer horizon helps ensure that future resource needs will be met, and if not, that market forces will encourage participation prior to that need.

Capacity resources may be new or existing and may include energy supply from generators, imported capacity, or demand capacity resources that reduce electricity consumption. Added resources must undergo a qualification process that ensures the future availability of committed supply. Annual and monthly “reconfiguration auctions” provide opportunities for the ISO to shed excess obligations or add additional ones.

Frequency Regulation

This is the effort to maintain electrical grid stability by ensuring all the energy generators are spinning at the same frequency, typically at 60 Hertz (Hz). Frequency is measured by the rate of spin per second and the definition of the term Hertz (Hz). Grid operators must maintain very tight thresholds on grid frequency to maintain stability.

Imbalance occurs when a sudden production surge (imagine a wind gust on a wind farm) suddenly supplies the grid creating an over-frequency event. Alternatively, a power plant goes offline and creates an under-frequency event. Over-frequency events are typically less problematic to solve, and automatic sensors typically kick in to reduce output.

Under-frequency events are inherently more challenging. Increasing production may require a dispatch call to a large power plant that requires time to adjust output. Storage batteries are very advantageous because they can be called to respond almost immediately to frequency regulation requests, responsiveness that grid operators value. However, small- or mid-scale energy storage on the distribution grid can run into challenges in the Frequency Regulation market due to the attendant costs of the telemetry equipment required to participate. Participating in the frequency regulation market requires a set aside for a fixed amount of capacity that would not be available for the day-ahead/real-time energy market.

Installed Capacity Reduction (ICAP)

ICAP management is a customer-centric savings mechanism that is tied to consumption by commercial uses. Programs often utilize an online service that presents a predictive model to alert customers when the grid demand is likely to peak. This knowledge provides an opportunity to proactively lower energy usage during the annual system peak-hour (aka “coincident demand”).

This peak-hour figure sets the value of an Installed Capacity Tag (ICT) that drives the following year’s capacity charges, a figure that accounts for 20 to 30 percent of the electric bill. Participants are required to have an interval meter (records electricity consumption every 30 minutes) with an ICT. Energy providers assign tags once annually, following the assessment period that runs from June 1st to May 31st.

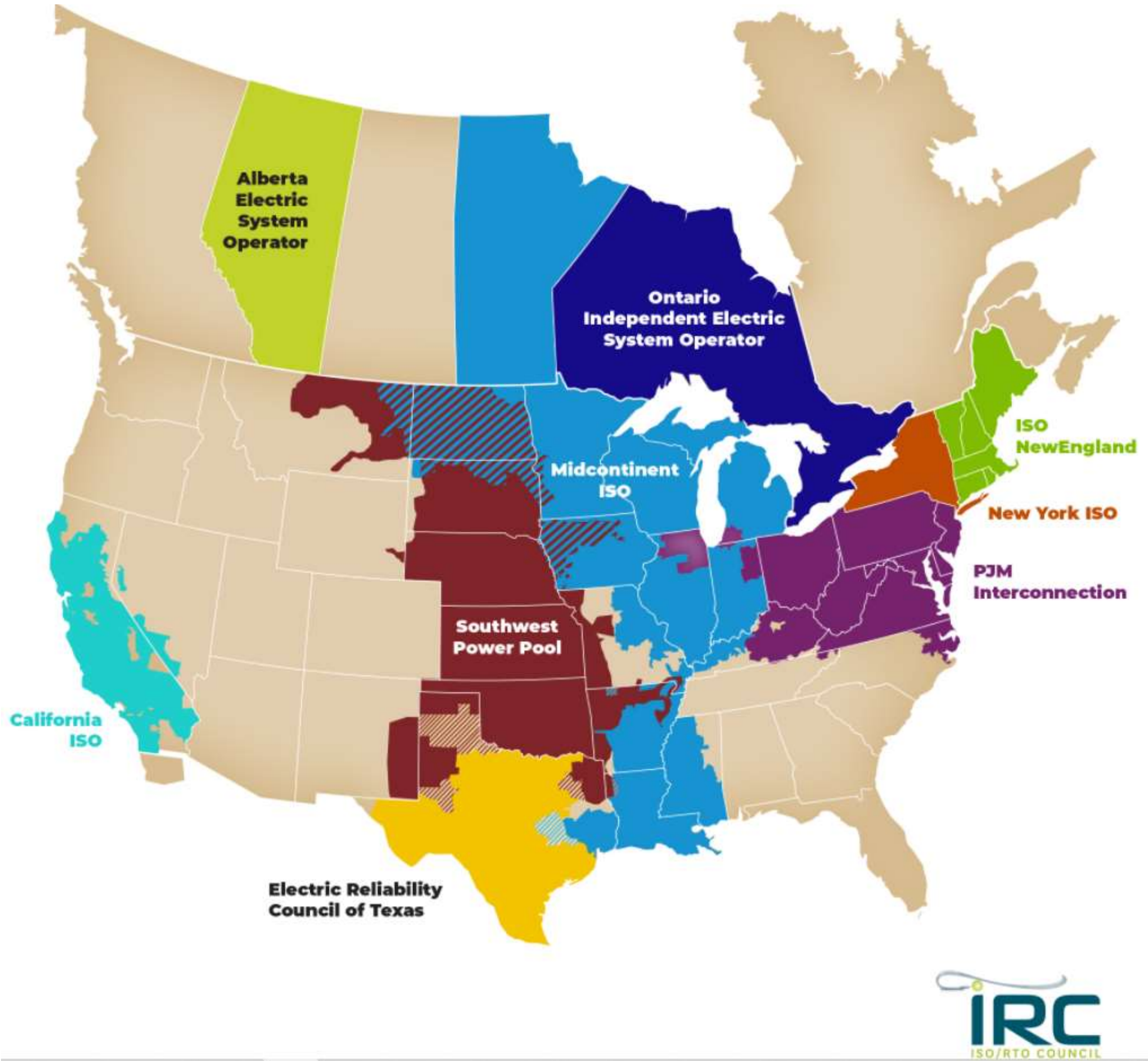
Investment Tax Credit (ITC)

The U.S. government currently offers a credit that can be claimed on federal corporate income taxes (i.e., not available for tax-exempt entities like charities) against the capital cost (purchase, install, and related equipment and soft costs) for new commercial solar photovoltaic systems and associated battery storage. In December of 2020, Congress extended the ITC to provide a federal tax credit of 26 percent of costs for systems commencing construction in 2020, 2021, or 2022, 22 percent in 2023, and 10 percent thereafter.

The battery portion of the tax credit is subject to a further reduction based on the percentage of stored energy produced by a renewable source (e.g., Solar PV generates 80% of stored battery energy, then the credit is reduced to 80 percent of capital cost). Importantly, the renewable source must generate at least 75 percent of the stored battery energy, or the tax credit is eliminated entirely.

Independent Service Operators (ISO)

Independent Service Operators (and their cousin Regional Transmission Operators or RTOs) operate the electricity transmission system and foster competition among market producers. ISOs establish and manage energy and related-service markets that use bid-based systems to optimize electricity output from generation facilities to meet current and future system loads at the lowest possible cost. While major sections of the southeast and west operate under more traditional wholesale market structures, two-thirds of the nation's electricity load is served within ISO/RTO regions.



Kilowatt (kW) and Megawatt (MW)

A kilowatt is a unit of power. One megawatt equals 1,000 kW. These figures represent the size of the discharge flow. A common analogy is a gas can. The size of the spout opening dictates how fast the gasoline can be poured out of the can. The kW or MW rating is the same, but for electricity.

Kilowatt-hour (kWh) and Megawatt-hour (MWh)

A kilowatt-hour is a unit of energy capacity. One megawatt-hour equals 1,000 kWh. A common analogy, again using the gas can analogy (see kW and MW), would be the quantity of fuel that is contained.

Local Property Tax Exemptions

Solar energy systems used as a primary or auxiliary power system for the purpose of heating or otherwise supplying the energy needs of taxable property may be exempt from local property tax for a 20-year period. This incentive requires the system owner to enter into an agreement with the city or town to provide a payment in lieu of taxes (PILOT) that equals at least 5 percent of its gross income during the prior calendar year.

The incentive applies only to the value added to a property by an eligible system and the components used exclusively by that system. It does not constitute an exemption for the full amount of the property tax bill.

Solar facilities that generate electricity to sell to the grid may be eligible for a Tax Increment Financing exemption agreement if they are in an Economic Opportunity or Economic Target Area. Facilities owned by electric generation or wholesale generation companies may be eligible for a payment in lieu of a tax agreement.

Changes to the exemption rules enacted under SB-9:

- Requires that an exempt project produce not more than 125 percent of the annual electricity needs of the property on which it is located, including non-contiguous real property within the same municipality in which there is a common ownership interest
- Limits the size of the eligible system to 25kW or less
- Overrules a prior decision to allow exemptions for a solar project located in one town that allocated bill credits to taxable properties in an adjacent town
- Extends the exemption to solar projects that "supply the energy needs" of property owned by tax-exempt nonprofit entities such as government buildings, schools, universities, nonprofit hospitals and other similar entities so long as the projects meet the 125 percent limitation across the entire campus
- Expands the exemption and PILOTs to include energy storage and fuel cells
- Standardizes the assessment process, terminology, terms, and tax policies across the Commonwealth

Regional Network Services (RNS)

Regional Network Service (RNS) is the transmission service to move electricity that transmission customers purchase to serve their network load in the New England Control Area.

Reliability

Reliability is achieved through the design, operation and maintenance of power supply to provide an adequate, safe and stable flow of electricity.

The ISO-NE has a Reliability Committee (RC) that is responsible for the design and oversight of reliability standards for the power system in New England. This committee focuses on short-term and long-term load forecasts to meet regulatory standards, the collection and exchange of system data for the future, standards and procedures to maintain a reliable and efficient power system in New England, plans for supply and demand-side resources, transmissions, and interconnections, procedures for dispatch infrastructure, and installed capacity requirements and ISO determinations on capacity requirements.

Resiliency

Resilience is directly linked to the concept of reliability, as a system cannot be resilient if it is not reliable. Resilience, however, is broader and tied to the preparation, operation, and subsequent recovery from significant events. It is also the ability to withstand extreme or prolonged events.

Resilience, from an energy perspective, is about ensuring a business has a reliable, regular supply of energy and contingency measures in place in the event of a power failure. Causes of resilience issues include power surges, weather, natural disasters, accidents and even equipment failure. The human operational error can also be an issue and should be factored into resilience planning. Ensuring a business is resilient may help insulate against energy price increases or fluctuations in supply and avoid delays or shutdown of their important processes that impact their ability to deliver goods or services. And while most power outages are shorter term in nature, there is a clear trend in the increasing number of large-scale natural weather events that can have broader, longer-term impacts. Critical industries, such as health care, senior centers, emergency services, and other critical industries will certainly become less susceptible to significant impacts as the resilience of the energy system improves.

Round Trip Energy Costs

Round trip energy costs reflect the net expense associated with recharging a battery storage energy resource. The expense reflects the fact that the amount of energy needed to charge a battery is more than the amount of energy that is discharged.

SMART Solar Incentives

The Solar Massachusetts Renewable Target (SMART) Program is a long-term sustainable solar incentive program operated by the Massachusetts Department of Energy Resources (DOER) with sponsoring electric utilities Eversource, National Grid and Unitil[36]. The program started in 2018 as a replacement for the Solar Renewable Energy Certificate (SREC) program. The programs' goal is to incentivize the development of 3,200 MW of solar generation in the Commonwealth.

The program pays participating photovoltaic system owners fixed incentive compensation rates for either 10 years (for ⩽ 25 kW AC) or for 20 years (for >25 kW AC). Variations to the incentive amounts depend upon location (i.e., behind the meter or within the home or building) and how the system is metered (net metering, quality facility tariffs, or alternative on-bill credit mechanism).

Additional incentive variables include the size of the system, the utility company, and the Capacity Block Compensation Rate (CPCR) set for the utility. The CPCR reflects the goal to encourage the development of "blocks" of solar energy within each of the respective energy company's operating districts, with set-asides for smaller installations (<25kW).

In addition to the base incentive rates, "adders" are provided to encourage solar development in certain settings (e.g., brownfield, building mounted, canopy, eligible landfills, agricultural), the inclusion of energy storage, and solar tracking capabilities. Off-taker (end-user) adders are available for solar installations that serve low-income areas, provide community shared resources, and serve public entities. Full

[36] https://masmartsolar.com/

program details, guidelines, and an incentive calculator can be found on the SMART program website (https://masmartsolar.com/).

Solar Photovoltaic (PV)

Photovoltaic technology (e.g., solar panel) converts light energy into electricity. In this case, that light source is the sun, thus solar. Solar arrays do degrade over time, with production losses typically averaging between 0.5 and 1.0 percent per year.

Appendix B: State & Federal Grant Programs, Incentives, and Capital Enhancements

The following State & Federal grant programs and other capital enhancements are defined to inform audiences with limited technical training about the universe of potential funding sources available to public and private microgrid investors. These resources may or may not be applicable to the technical solutions under consideration by the Town of Natick, depending on the ultimate renewable energy system and associated funding mechanism implemented by the Town.

Biden Bipartisan Infrastructure Framework

When fully implemented, the federal government's recently passed infrastructure legislation represents a potentially significant source of funding for energy and related infrastructure projects. The framework identifies total funding of $1.2 trillion, allocated within three broad utility, transportation, and pollution remediation categories. Bringing projects closer to a "shovel-ready" status may be an important attribute to secure funds as they are allocated.

Utility Investments	Total $ (Billions)
Power Infrastructure	$73
Broadband	$65
Water Infrastructure	$55
Resilience	$47
Western Water Infrastructure	$8
Subtotal	$240

Transportation Investments	Total $ (Billions)
Roads and Bridges	$110
Railroads	$66
Public Transport	$39
Airports	$25
Ports and Waterways	$17
Electric Vehicles	$15
Road Safety	$11
Reconnecting Communities	$1
Subtotal	$284

Pollution Remediation	**$21** B

Building Resilient Infrastructure and Communities (BRIC) Grants

BRIC Grants provide states, local communities, tribes and territories funding for eligible mitigation activities that build a culture of preparedness, thus reducing disaster losses and protecting people and property from disasters. Total funding in FY2020, the most recently completed cycle, totaled $700 million.

Under this program, each state must designate an agency to serve as the Applicant for BRIC funding to submit a single application to FEMA. An application can be made up of an unlimited number of sub applications. Local governments, including cities, townships, counties, special district governments, state agencies, and tribal governments, are considered sub applicants.

Sub applicants must have a FEMA-approved Hazard Mitigation Plan by the application deadline and at the time of obligation of grant funds for mitigation projects and Capability and Capacity Building activities (C&CB).

Projects must:

1. Be cost-effective
2. Reduce or eliminate risk and damage from future natural hazards
3. Meet either of the two latest published editions of relevant consensus-based codes, specifications, and standards
4. Align with the applicable hazard mitigation plan
5. Meet all environmental and historic preservation (EHP) requirements

In 2018, Massachusetts received a BRIC Grant support funding of the State Hazard Mitigation and Climate Adaptation Plan (SHMCAP). The plan was the first all-hazard mitigation plan that integrated climate impacts and adaptation strategies to address two primary hazards: coastal flooding and winter storm impacts. The planning process was managed through the Executive Office of Energy and Environmental Affairs (EOEEA), the Executive Office of Public Safety and Security (EOPSS), and the Massachusetts Emergency Management Agency (MEMA). Additional background on the BRIC Grant Program and the full case study description of SHMCAP and other successful sub applicants can be found on the FEMA website (FEMA Hazard Mitigation Action Portfolio).

The fiscal year 2021 (FY 2021) application period for the Hazard Mitigation Assistance (HMA) Notices of Funding Opportunities (NOFOs) for the Building Resilient Infrastructure and Communities (BRIC) grant programs opened on Sept. 30, 2021. This annual application cycle closes at 3 p.m. EST on Jan. 28, 2022.

DOE Loan Guarantees (Title 17 Innovative Energy Loan Guarantee Program)

The Loan Programs Office (LPO) has facilitated more than $40 billion in loans to deploy large-scale energy infrastructure projects in the United States. Over the past decade alone, LPO has participated in more than $30 billion of investment across a variety of energy sectors. Like Green Banks, the DOE's role in financial transactions is one of facilitation, providing financial guarantees that lower the risk for private capital sources.

The LPO's typical role is to bridge financing gaps in the commercial debt market when innovative technologies may not be well understood by the private sector. Project types often include large-scale commercial energy projects, research-development-and-demonstration (RD&D) projects, and smaller projects as well.

Current loan guarantee authorities include:

6. $8.5 billion in for innovative advanced fossil energy projects
7. $10.9 billion in loan guarantee authority for innovative advanced nuclear energy projects
8. $17.7 billion to support U.S. manufacturing of fuel-efficient, advanced technology vehicles

9. $4.5 billion for innovative renewable energy & efficient energy projects
10. $2 billion in partial loan guarantee authority for tribal energy development projects.

Basic eligibility requirements include:

11. A new or significantly improved technology
12. Reduction or sequestration of greenhouse gases
13. Location in the United States
14. Expectation for repayment

Additional information can be found at https://www.energy.gov/lpo/application-process

EPA Grants

The EPA has several grant opportunities for green infrastructure.

EPA Clean Water State Revolving Fund (CWSRF)—The CWSRF program is a federal-state partnership that provides communities a permanent, independent source of low-cost financing for a wide range of water quality infrastructure projects, including stormwater and green infrastructure.

EPA Office of Wetlands, Oceans, and Watersheds (OWOW) Funding—OWOW has created this website to provide tools, databases, and information for practitioners that serve to protect watersheds.

EPA Brownfields Grant Program—EPA's Brownfields program provides direct funding for Brownfields assessment, cleanup, revolving loans, and environmental job training. To facilitate the leveraging of public resources, EPA's Brownfields Program collaborates with other EPA programs, other federal partners, and state agencies to identify and make available resources that can be used for Brownfields activities.

https://www.epa.gov/green-infrastructure/green-infrastructure-funding-opportunities

Green Bonds

A green bond (climate bond) is a type of fixed-income instrument that is specifically earmarked to raise money for climate and environmental projects. These bonds are typically asset-linked and backed by the issuing entity's balance sheet, so they usually carry the same credit rating as their issuers' other debt obligations.

Green bonds come with tax incentives such as tax exemption and tax credits, making them a more attractive investment compared to a comparable taxable bond. These tax advantages provide a monetary incentive to tackle prominent social issues such as climate change and a movement toward renewable sources of energy. To qualify for green bond status, they are often verified by a third party such as the Climate Bond Standard Board, which certifies that the bond will fund projects that include benefits to the environment.

Green Banks

Green Banks are public, quasi-public or non-profit entities established specifically to facilitate private investment into domestic low-carbon, climate-resilient infrastructure. They are publicly capitalized, and their efforts are mission-driven (versus profit-driven) that use financing to accelerate the transition to clean energy and address the impacts of climate change. Additional components of Green Bank missions may include elements that support equity and low-income communities. Green Bank capital is most often leveraged to attract private capital into deals by de-risking deal terms through credit guarantees and other financial means.

Massachusetts Clean Water Trust

The Massachusetts Clean Water Trust (the Trust) is a state agency that improves the water quality throughout the Commonwealth by providing low-interest loans to municipalities and other eligible entities. This program may be relevant to microgrid projects serving water and water treatment infrastructure.

According to the 2020 Green Bond Report, the Trust:

15. Helps communities build or replace water quality infrastructure that enhances ground surface water resources, ensures the safety of drinking water, protects public health, and develops resilient communities.
16. Provides low-interest loans and grants to cities, towns, and water utilities through the Massachusetts State Revolving Funds (SRF)
17. $7.6 billion in water infrastructure projects financed from $2.6 billion in federal grants and state matching funds
18. $998.4 million bonds issued as Green Bonds

Eligible Projects:

19. Wastewater treatment projects
20. Infiltration/inflow and sewer system rehabilitation projects
21. Collector and interceptor sewer projects
22. Combined sewer overflow (CSO) correction projects
23. Non-point source (NPS) sanitary landfill
24. Planning projects – developing plans to address water quality and related public health problems
25. Drinking water treatment projects
26. Drinking water transmission and distribution projects
27. Drinking water source and storage projects
28. Drinking water planning and design projects