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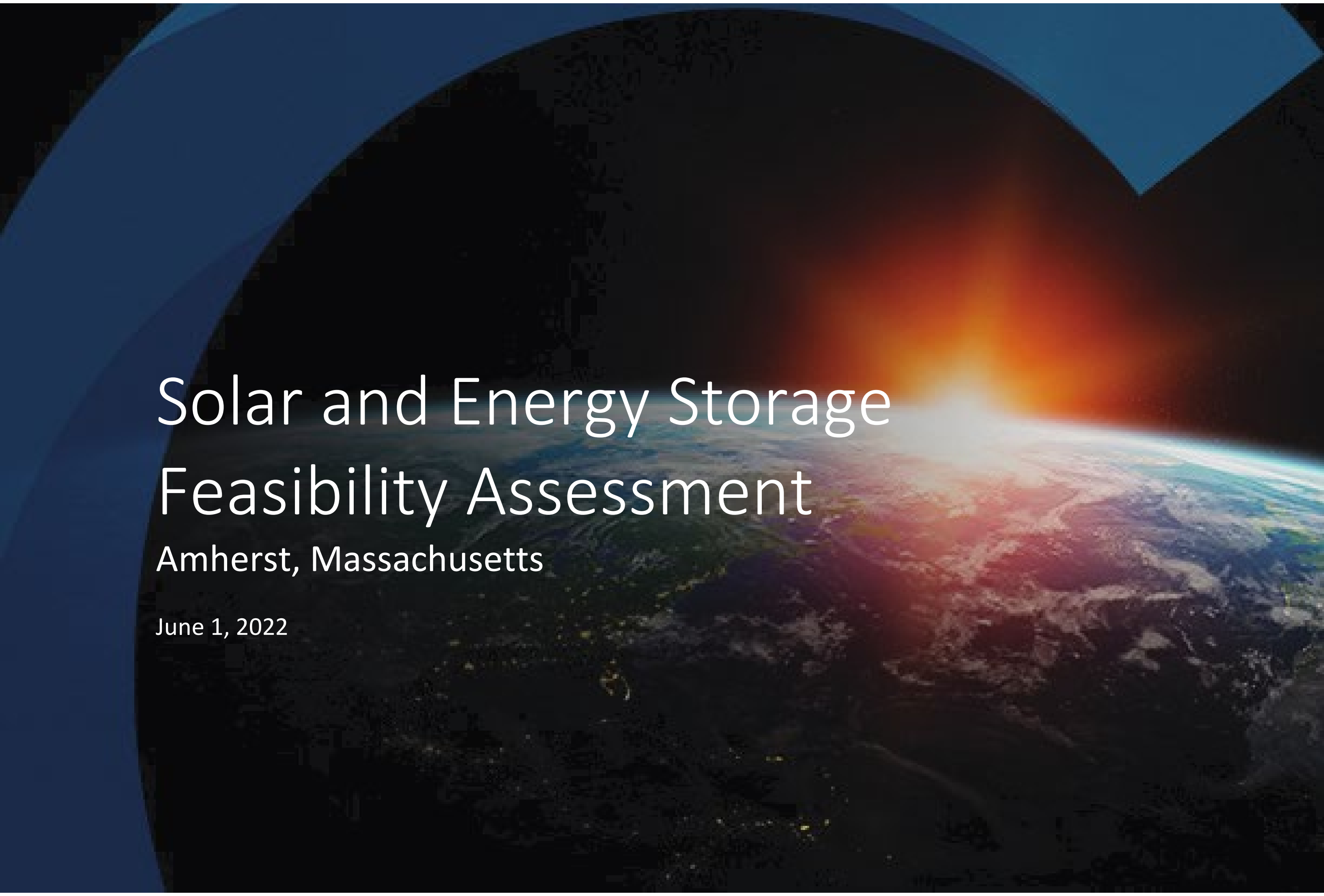

Solar and Energy Storage Feasibility Assessment

Amherst, Massachusetts

June 1, 2022

Prepared for:

Town of Amherst and
Amherst-Pelham Regional School
District

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Executive Summary

The Cadmus Group (Cadmus) has prepared this report for the Town of Amherst and Amherst-Pelham Regional School District (for simplicity, herein referred to jointly as the "Town") to evaluate the feasibility of solar photovoltaic (PV) and battery energy storage systems (ESS) at ten sites. This report contains the results of the assessment, a discussion of solar PV and battery ESS technology basics, and financing options available to the Town.

This report is intended to inform the Town in its decision-making process regarding which solar PV and ESS projects and configurations to pursue, as well as to serve as a point of reference when reviewing developer responses to a Request for Proposal (RFP). Ultimately, the solar PV and ESS designs, financing models, and prices offered will be determined by the responding developers.

Table 1 provides an overview of the PV and ESS scenarios modeled and summary findings. All scenarios were modeled for 20 years of operation, so the lifetime net present value (NPV) savings represent estimated savings for 20 years from project completion, relative to business as usual (no solar or ESS installations). Lifetime NPV savings are largely driven by the site solar potential and required battery size to meet demand during an outage. Sites with higher solar potential (e.g., all school sites) have greater lifetime NPV savings, while sites with limited solar potential and large battery size requirement—especially the police station—have lifetime negative NPV relative to business as usual.

The maximum 20-year NPV savings ($4,095,112) that could be achieved from using all modeled scenarios is offered by:

1. Sizing all batteries for a 24-hour outage,
2. Sizing a battery at the police station to meet 50% of on-site load during an outage, and
3. Strategically removing some trees at the Bangs Community Center and Crocker Farm Elementary School to increase solar PV potential.

These savings figures do not include tree removal costs or other financial considerations not listed in Appendix A. Site Analyses.

Table 1. Sites Overview and Summary Findings

Site	Scenario	PV Capacity (kW-DC)	Year 1 PV Generation (kWh)	Outage Duration	ESS Size (kW / kWh)	Lifetime NPV Savings ($)
Bangs Community Center	Roof + Carport	91.7	105,350	24	70 / 668	$(29,931)
				48	70 / 739	$(76,945)
	Roof + Carport, tree removal	129.2	156,267	24	64 / 462	$157,360
				48	64 / 513	$122,790
Amherst Police Department	Roof + Carport, 100% CLF*	39.6	49,949	24	132 / 2319	$(1,337,070)
				48	132 / 4583	$(2,896,882)
	Roof + Carport, 50% CLF			24	64 / 1045	$(419,777)
				48	64 / 2120	$(1,150,373)
North Fire Station	Roof + Carport	98.4	116,823	24	35 / 492	$(136,567)
				48	35 / 591	$(201,278)
Crocker Farm Elementary School	Roof + Carport	334.4	403,956	24	100 / 419	$506,368
				48	100 / 466	$477,706
	Roof + Carport, tree removal	378.9	457,487	24	100 / 384	$591,866
				48	100 / 431	$567,970
Amherst-Pelham Regional High School	Roof + Carport	1,541.8	1,875,922	24	385 / 2736	$960,448
				48	385 / 3632	$484,528
Amherst Regional Middle School	Roof + Carport + Ground	1,258	1,505,097	24	315 / 1012	$2,876,535
				48	315 / 1432	$2,778,797
	Roof + Carport	1,037	1,249,803	24	259 / 2183	$775,678
				48	259 / 2760	$385,271
Spring Street Lot	Carport	86.6	110,093	-	-	$28,214
Pray Street Lot	Carport	99.9	117,233	-	-	$5,287
Boltwood Garage	Carport	180.2	213,332	-	-	$31,241
Cherry Hill Golf Course	Carport	13.3	15,926	-	-	$505
TOTAL	**Min**	3,522.9 kW-DC	4,258,387 kWh	24	-	$804,173
				48		$(1,762,353)
	Max	3,825.9 kW-DC	4,618,129 kWh	24	-	$4,095,112
				48		$2,667,681

* CLF: Critical load factor, the percentage of load to be met during an outage

Note: red text indicates that the scenario results in overall negative NPV to the Town over the lifetime of the project, relative to business as usual.

Summary of Findings

Estimated lifetime savings are closely related to the site's solar potential and outage scenario.

Sites with the greatest solar potential (High School, Middle School, and Crocker Farm Elementary School) have the highest estimated lifetime savings relative to business as usual. These savings are primarily generated from participation in net metering, solar incentive payments from the SMART program, and revenues from battery participation in demand response (ConnectedSolutions) and the Clean Peak Standard Program.

The two Town properties with the lowest solar potential (Police Department, North Fire Station) are projected to generate negative NPVs relative to business as usual. This is due to the limitations on recouping the capital investments through net metering, solar incentive payments from SMART, and battery program participation. The Police Station has the most negative lifetime NPV due to high on-site usage and demand. The high demand requires a larger battery to meet needs during outages, which results in high capital costs due to the limited ability of solar to charge the battery or offset load.

In all scenarios, estimated lifetime savings are higher for batteries sized for a 24-hour outage. For a longer outage, batteries need to be sized with a greater capacity (kWh), which are more expensive.

Strategic tree removal may significantly increase lifetime savings.

The two Bangs Community Center scenarios—one with existing conditions and one with strategic tree removal—demonstrate that strategic tree removal can significantly impact the lifetime savings of installing solar and storage on-site. By strategically removing a few trees, the on-site solar capacity increases from 92 kW DC to 129 kW DC. This 40-kW increase in solar size results in around $160,000 lifetime savings, versus around $30,000 in lifetime costs without strategic tree removal (24-hour ESS size). The large difference is driven by the ability of the larger array to meet up to 75% of on-site load (compared to 50% with smaller array) and provide more energy to on-site load during the outage scenarios. With more solar available during outages, the facility is sized with a smaller battery, reducing upfront costs.

Excess energy produced can be virtually net metered to other sites.

Overall, the potential generation from solar at the modeled sites is estimated to exceed on-site generation by 18% (net 637,000 kWh). With strategic tree removal and a ground mount included at the Middle School, solar generation is estimated to exceed on-site generation by 28% (net 996,000 kWh). This excess generation can be virtually net metered to other Town electric accounts, to further reduce electricity bill costs.

Using a third-party ownership model (PPA agreement) requires zero upfront costs for the Town.

All modeled scenarios result in a third-party owner internal rate of return of 8.3% and a payback period of less than 10 years, which satisfy standard developer investment requirements.

Introduction

The Cadmus Group (Cadmus) has prepared this report for the Town of Amherst and Amherst-Pelham Regional School District (for simplicity, herein referred to jointly as the "Town") to evaluate the feasibility of solar photovoltaic (PV) and battery energy storage systems (ESS) at ten sites. This report contains the results of the assessment, a discussion of solar PV and battery ESS technology basics, and financing and ownership models available to the Town. This report is intended to be used as a resource and tool for the Town to make informed decisions about which solar PV and ESS projects and configurations to potentially pursue, as well as to serve as a point of reference when reviewing developer responses to a Request for Proposal (RFP). Ultimately, the solar PV and ESS designs, financing solutions, and prices offered, will be determined by the responding developers.

Cadmus evaluated the technical and economic feasibility of ten properties in this report: ***Bangs Community Center, Amherst Police Department, North Fire Station, Crocker Farm Elementary School, Amherst-Pelham Regional High School, Amherst Regional Middle School, Spring Street Lot, Pray Street Lot, Boltwood Garage, and Cherry Hill Golf Course.*** For each site, Cadmus performed a desktop analysis of the solar PV potential using satellite images and monthly utility bills provided by the Town. Using this data, Cadmus created solar PV array designs for the sites. To model ESS sizing and savings, Cadmus used pertinent site-specific information provided by the Town, including site plans and utility bills, which indicated the rate structure, electricity usage and demand, and monthly costs for the sites. Cadmus used this information, along with capital costs by technology, to model estimated lifetime savings relative to business as usual for each site.

The following sections detail solar PV and energy storage scenarios the Town could pursue, reducing carbon emissions while saving energy and money. The sections detailed in this report include:

- Solar and Energy Storage Considerations
- Project Ownership Options
- Incentives and Grants
- Technical and Financial Feasibility Analysis
- Recommendations

Further details are provided in the Appendices:

- Appendix A. Site Analyses
- Appendix B. SMART Program Information
- Appendix C. Clean Peak Standard Program Information
- Appendix D. ConnectedSolutions Program Information

Solar and Energy Storage Considerations

This section provides an overview for the Town on key considerations for solar PV and energy storage system deployment.

Solar PV Considerations

A solar PV system offers a variety of benefits, including energy cost reductions, incentive revenues, energy price stability, leading by example, and carbon emissions reductions. Solar PV systems capture the sun's energy and convert it into electricity to be used on-site by a building, delivered to the electricity grid, or stored in an energy storage system. The three most common solar PV system installation types are roof-mounted, ground-mounted, and solar carports or parking canopies. The type of solar PV system, and associated land use implications, are important to consider when deciding among system types. Solar PV systems on already-developed land (such as roof-mounted systems, capped landfills, or parking canopies) are often eligible for additional incentives. A solar PV system may or may not include a battery energy storage system, but it is generally important to know if an ESS installation is intended at the start of the project.

There are some basic characteristics that help determine whether a solar PV system is suitable for a site. Key considerations include avoiding shading or other obstructions to development, orientation to the sun, available space, age of the roof, and any other site-specific details that may impact development, such as watershed setbacks.

During an installation, a solar PV system will need to be integrated with building electrical systems, which may require upgrades to utility or on-site infrastructure. Having building documents up to date and available will help the installer evaluate the electrical readiness of a property. If electrical upgrades are needed for a safe and code-compliant solar PV system installation, they may add to the total cost of the project. In most cases, a solar PV system will be connected to the electrical grid. Massachusetts provides a thorough guide to Distributed Generation and Interconnection in Massachusetts, which includes utility interconnection rules and application processes and timelines.[1]

Integrating Solar PV and Energy Storage

With recent updates to state policies and incentive programs, battery energy storage systems paired with solar PV are becoming an increasingly attractive option for property owners in Massachusetts. Integrating storage systems with solar PV provides added benefits, including demand charge reductions, increased resilience, and environmental benefits. An energy storage system makes it possible to store electricity generated during the day to be used at another time. Battery energy storage systems have two key design characteristics: energy capacity and power. Energy capacity is the amount of energy that can be stored in a battery and is measured in kilowatt-hours (kWh), while power, measured in kilowatts (kW), is the amount of energy that can be delivered at one time.

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[1] Massachusetts Department of Energy Resources (DOER). Utility Interconnection in Massachusetts. https://www.mass.gov/info-details/utility-interconnection-in-massachusetts#utility-interconnection-reports-

Generally, solar PV will shift a facility's load profile from a broad mid-day peak to a narrower late-afternoon peak. Energy storage can be discharged during the narrower peak to achieve greater demand charge savings. Solar and storage resources can also provide power for emergency loads during longer grid disruptions. Additionally, ESS can be utilized to reduce grid export from PV systems, though this may marginally decrease overall savings to the Town. Finally, stakeholders may value the environmental benefits of charging the storage system from an on-site renewable energy source, rather than the electric grid. To maximize energy savings and revenue generation potential, storage developers try to deploy ESS with multiple use cases.

Energy Storage Considerations

There are many use cases for energy storage systems. These include resilience, energy arbitrage, demand reduction, and demand response.

Resilience

Solar PV systems, when paired with ESS, can provide buildings with alternative energy generation options during grid interruptions, similar to a back-up diesel generator. When combined, solar PV and energy storage can effectively provide back-up power for critical facility functions during power outages, releasing energy when called upon. Storage increases the resiliency of a facility's power supply and support critical electric services during power failure. Critical services can be determined on a per-facility basis and might include heating and cooling, emergency lighting, and elevator operation.

Demand Charge Reductions

Solar PV and storage systems can potentially reduce the demand charges for monthly peak energy consumption. Depending on level of consumption and utility rate structure, demand charges can be as much as 70% of a facility's electric bill.

Energy Arbitrage

Property owners subject to variable electricity pricing can reduce their electric bill by using behind-the-meter energy storage. By charging the storage system when utility electricity prices are low and discharging when prices are high, facilities can shift consumption to lower-cost electricity periods. For each facility, there is a specific price difference required for this strategy to make financial sense to pursue.

Demand Response

Demand response programs compensate participants for energy they export to the utility grid when utility-wide demand is high and system reliability is at risk. Under the demand response use case, utilities will send a signal for battery energy storage systems to discharge to help reduce system-wide peaks on the electricity grid. To participate in these programs, owners can strategically manage energy usage with their storage systems, leaving a set energy reserve to export during these periods of high demand. These programs are participation-based incentives, where a greater amount of energy discharged during these events results in greater compensation.

Additional Energy Storage Considerations

The use cases of battery energy storage systems will depend on the utility, rate structure, government incentives and the facility's internal pattern of energy use (load pattern). The following factors are considered when evaluating storage feasibility:

- **How important is a backup power supply to the property's operations?**
    - Facilities that require constant power supply (e.g., fire stations, emergency response centers, police, or critical infrastructure such as water treatment and supply and wastewater treatment) could be good candidates for on-site storage. Some energy storage systems may provide uninterrupted power supply for all functions (on the scale of seconds and minutes), along with long-term power supply for critical functions (on the scale of hours) and provide resilience benefits during power outages or an emergency.

- **Is there an appropriate location on site for the storage system?**
    - A storage system can be placed indoors or outdoors but must be in a well-ventilated location with appropriate safety features. A developer will help a customer understand appropriate siting options and the level of compatibility storage may have with the building's current electrical system. Local building and fire departments should be involved early in the decision-making process, particularly when energy storage is under consideration.

- **What incentive programs are available to the storage system?**
    - Most storage systems are only financially lucrative when there are multiple incentive structures in place for the system to participate in. These include time-of-use electricity pricing, demand charges, the SMART program, targeted performance-based incentives (ConnectedSolutions, Clean Peak Program), tax incentives and rebates.

- **How significant are the demand charges on the electricity bill?**
    - Large electricity customers often have demand charges on their utility bill, which are charges based on the maximum amount of electricity (kW) used during a day. Installers will evaluate the ratio of kW-to-kWh charges on their electric bill. If the demand charges make up a considerable portion of the total electric bill charges, then the site may be particularly suitable for storage. When a facility's peak demand is high, battery energy storage systems can lower those peaks and help reduce demand charges.

Project Ownership Options

This section outlines the solar PV and energy storage system ownership options available to the Town.

Direct Ownership

Direct ownership is a structure where the municipality purchases the solar PV system from the installer. Direct ownership normally allows the property owner to collect all eligible federal and state tax benefits and utilize state and local financial incentives. However, municipalities are not eligible for the tax credit incentives, though are eligible for other state incentives. There are several ways that municipalities have financed a system purchase, including through capital improvements, grants or bonds. Under a direct ownership scenario, the municipality is responsible for the capital cost of installation, which is often significant. It is important to note that municipalities often use a third-party ownership model to avoid sacrificing the tax credit value, which is the ownership model used in this analysis.

Third-Party Ownership

With a third-party ownership model, the solar installer or a financing partner owns the solar PV system on the municipal property and is responsible for operations and maintenance. The third-party partner collects the tax benefits and financial incentives, including the Federal Investment Tax Credit (ITC), and passes a share of the savings on to the electricity buyer, usually in the form of lower energy costs. Under third-party ownership, there are several options for the property owner to benefit from the solar PV system, the most common of which is a power purchase agreement (PPA)**.** A PPA is an agreement between the third-party system owner, brokered by the solar installer (may be the same or different entity). The system owner sells the electricity produced by the system to the property owner at an established fixed price per kilowatt hour. The fixed electricity price is typically lower than the standard utility rate, so the property owner receives immediate savings through reduced energy costs.

Other third-party ownership options include a site lease agreement between a property owner and solar installer (or a third party) in which the third-party builds, owns, and operates a solar electric system on a host site. The property owner will receive benefits in the form of site lease payments from the third party. This may be paired with a PPA with the property owner, or the developer may elect to sell the electricity to a utility or another entity. A production guarantee is often included if paired with a PPA or structured as the leasing of the equipment.

Another more complex option under third-party ownership is the use of a tax equity financing partner, where a third-party investor takes passive ownership to receive the tax benefits and cash return on investment. This model blends the ownership options and may be an option for property owners who favor direct ownership, but don’t have the tax liability needs.

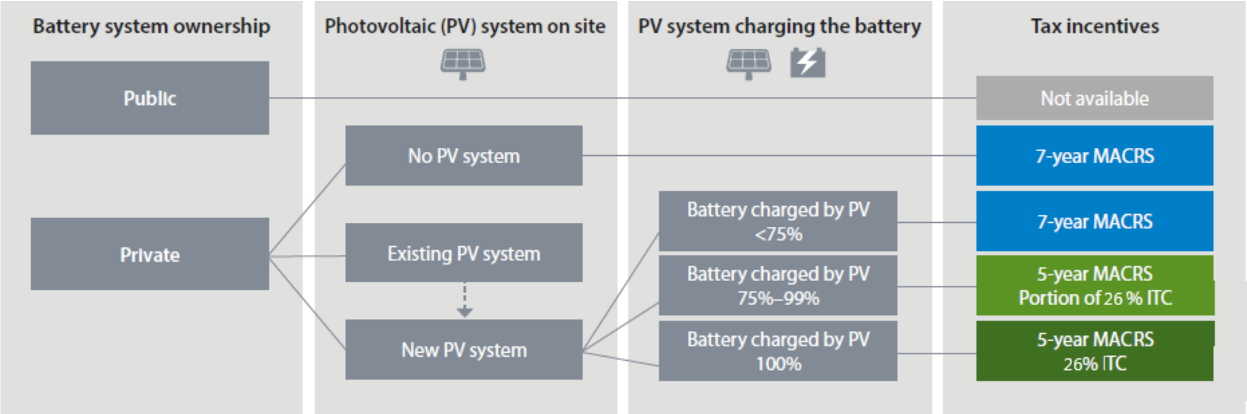
Incentives and Grants

This section details the solar PV and energy storage system incentives and grant programs available to the Town.

Federal Investment Tax Credit (ITC)

Solar PV and ESS projects are typically eligible for the Federal Investment Tax Credit (ITC), which allows the owner to receive a one-time tax credit on federal taxes equal to a percentage of the project cost (per Section 48 of the Internal Revenue Code).[2] In late 2020, the ITC step-down schedule was pushed out as part of COVID-relief: projects beginning construction through the end of 2022 will be eligible for a 26% credit; the credit declines to 22% for 2023 and then drops down to 10% thereafter. As mentioned above, public projects would only be able to realize savings associated with the ITC if they partner with a private third-party that is eligible. Generally, solar PV and BESS systems also qualify for the five-year Modified Accelerated Cost-Recovery System (MACRS) depreciation schedule. The Tax Cuts and Jobs Act of 2017, however, allows for 100% bonus depreciation (in year one) for solar projects through the end of 2022. The rate steps down by 20 percentage points each year thereafter (i.e., 80% in 2023, 60% in 2024, etc.). Figure 1 depicts tax incentives available for various solar PV and BESS configurations.

Figure 1. Federal Tax Incentives for Energy Storage Projects[3]



Solar Massachusetts Renewable Target (SMART) Program

Massachusetts offers incentives for grid-connected solar PV projects in investor-owned utility service territories through the Solar Massachusetts Renewable Energy Target (SMART) program.[4] The SMART Program is a tariff-based incentive program designed to support the installation of 3,200 MW of solar generation in the Commonwealth. The SMART program provides solar PV system owners with incentives

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[2] EnergySage. The Solar Tax Credit: a federal energy tax credit for going solar (2021). Retrieved from https://www.energysage.com/solar/cost-benefit/solar-investment-tax-credit/#:~:text=The%20investment%20tax%20credit%20(ITC,no%20cap%20on%20its%20value.

[3] National Renewable Energy Laboratory (NREL). Federal Tax Incentives for Energy Storage Systems (2018). Retrieved from https://www.nrel.gov/docs/fy18osti/70384.pdf

[4] Massachusetts Department of Energy Resources (DOER). Solar Massachusetts Renewable Energy Target (SMART) (2021). Retrieved from https://www.mass.gov/info-details/solar-massachusetts-renewable-target-smart-program

for renewable energy production. Organizations that own the solar electric system will receive the incentive benefit directly, while organizations that opt for third-party ownership will receive the incentive indirectly via the negotiated PPA or lease price. The program provides solar projects an incentive payment in exchange for the environmental attributes of the solar power. A description of how this incentive payment is calculated can be found in Appendix B. SMART Program Information.

Net Metering

Net metering has provided an important revenue stream for renewable energy projects. It allows projects that generate electricity behind the meter—i.e., systems that import and export to the electrical grid—to generate net metering credits for excess generation. Every month, any electricity produced that was not consumed on-site generates net metering credits. These credits are used to offset present and future electric bills, potentially reducing bills to zero. There are set caps on the allowable amount of net metering capacity by service territory and facility type (public or private). Any solar PV projects the Town is associated with would fall under the public Eversource cap, which has 20 MW remaining (10 MW for the Town of Amherst and 10 MW for the Amherst-Pelham Regional School District).[5]

Virtual net metering is a structure that allows the Town to realize the financial benefits of renewable generation from projects without onsite consumption. Previous legislation had excluded virtual net metering to occur across separate ISO-NE load zones. In March 2021, Massachusetts Governor Baker signed *An Act Creating a Next-Generation Roadmap for Massachusetts Climate Policy*. The bill contains detailed information related to transportation and energy policy, and a few key items that will impact the Town, with the chief item being virtual net metering. The bill features language in Section 96 that allows for new solar facilities constructed on or after January 1, 2021 to be eligible to virtually allocate credits for excess generation to facilities within the same distribution company, regardless of ISO-NE load zone. The Massachusetts Department of Public Utilities has yet to issue any further rulemaking further detailing this process, so the measure has not yet gone into effect at the time of this report.

Clean Peak Standard (CPS)

The Massachusetts Clean Peak Standard is a performance-based storage incentive program.[6] Participating system owners generate Clean Peak Energy Credits (CPECs) by producing or exporting energy to the electric grid during peak load hours. Participating systems report their production or energy exports to the program administrators and receive credits based on coincidence with peak hours, multiplied by a number of system-specific multipliers. Each year, retail electricity providers are required to purchase a certain amount of CPEC’s based on a percentage of their total yearly sales. Eligible systems include Demand Response Resources, Qualifying Energy Storage Systems, and Qualified RPS Resources like solar PV arrays. Any PV system that is enrolled in the SMART program, however, forfeits the CPEC’s generated by the PV system to the utilities. Any CPECs generated by an ESS connected to a SMART program PV system is still held by the system owner but has a multiplier (0.3) to avoid double-counting across incentive

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[5] System of Assurance of Net Metering Eligibility Public Entity Cap Tracker. Retrieved from https://app.massaca.org/PublicEntity10MWCapTracking/Report.aspx

[6] State of Massachusetts. Clean Peak Energy Standard Guidelines, 225 CMR 21.00 (2021). Retrieved from https://www.mass.gov/info-details/clean-peak-energy-standard-guidelines

programs. More details on CPEC calculations are available in Appendix C. Clean Peak Standard Program Information.

ConnectedSolutions (CS)

The ConnectedSolutions program covers the majority of the Commonwealth of Massachusetts and involves cooperation from all electric utilities in the state, including Eversource. The program aims to utilize distributed energy storage assets from residential, commercial, and industrial customers for grid-wide demand response and peak shaving. Electric service in much of Massachusetts is relatively reliable, therefore blackout and brownout management and islanding are of lower priority compared to grid peak shaving, which offers the greatest ability to reduce utility operational costs. The incentive is calculated based on average instantaneous load reduction (in kW) throughout the duration of all demand response events. In order to participate in ConnectedSolutions, the site needs to pay into the Energy Efficiency Fund, which all Amherst sites do. The current incentive values and additional information is provided in Appendix D. ConnectedSolutions Program Information.[7]

Municipal Vulnerability Preparedness (MVP) Action Grant

The Massachusetts Executive Office of Energy and Environmental Affairs (EEA) sponsors grants for financial and technical assistance for projects in communities designated as Climate Change Municipal Vulnerability Preparedness Communities (MVP Communities). The FY 2022 grant update includes a provision for an “energy resilience” project type. This new project type would allow grant funding to be used for clean energy generation paired with resilience-enabling technologies such as energy storage and microgrids at eligible critical facilities. Eligible facilities include emergency personnel dispatch, facilities which support municipal emergency operations, and health services facilities, among others. Awards range from $25,000 to $2,000,000 and applicants must provide a 25% match of the total project cost.[8]

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[7] Eversource ConnectedSolutions Demand Response guide for commercial and industrial customers. Retrieved from https://www.eversource.com/content/docs/default-source/save-money-energy/storage-demand-response.pdf?sfvrsn=4f39c962_4

[8] COMMBUYS Operational Services Division. Bid Solicitation: BD-21-1042-ENV-ENV01-59692 (2021). Retrieved from https://www.commbuys.com/bso/external/bidDetail.sdo?bidId=BD-21-1042-ENV-ENV01-59692

Technical and Financial Feasibility Analysis

The feasibility assessment includes both a technical and a financial analysis for each site. The technical analysis outlines the potential design, capacity, and annual electricity generation of PV systems, as well as opportunities to deploy battery energy storage systems. The Cadmus team worked with the Town to conduct preliminary, remote site analyses for each of the Town's sites using Helioscope, a web-based PV design software.[9] In Helioscope, Cadmus modeled roofs using the tilts and dimensions indicated in the site plans and accounted for planned changes that affect panel installation, like tree removal. Shading considerations, such as nearby trees, were also included in the model. Helioscope calculates system energy production for each day of the year, adjusting for sun direction and intensity. The ESS and financial analyses were performed using REopt, an open-source, techno-economic software model developed by the National Renewable Energy Laboratory (NREL) to estimate the performance and cost of renewable energy systems.[10]

The estimated annual solar PV production modeled in this analysis can be used to project annual energy savings for the Town. Site-specific energy savings are expected to continue over a 20-year timeline with minimal (approximately 0.5%) annual performance degradation in solar generation. For each design, Cadmus maintained industry-standard technology assumptions, including the use of 370-Watt panels and inverters optimized to produce accurate PV generation estimates. As designed, the PV systems modeled also ensure that no roof-mounted solar PV system would cause the shedding of ice or snow from the roof into a porch, stairwell, or pedestrian travel area. Cadmus ensured these safety requirements were met by incorporating setbacks and access pathways that exceeded the minimum requirements as defined in the National Fire Protection Association Fire Code.[11] In the solar PV design images, each blue rectangle represents a single PV module, while orange shaded areas represent keepouts—areas where solar PV would not be supported due to preexisting obstructions or the safety requirements mentioned above.

Site-by-site technical and economic solar PV and ESS feasibility analyses are available in Appendix A. Site Analyses.

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[9] Helioscope. Retrieved from https://www.helioscope.com/

[10] NREL REopt Lite Web Tool. Retrieved from https://reopt.nrel.gov/

[11] National Fire Protection Association (NFPA) 1, 2015. Section 11.12 Photovoltaic Systems. Retrieved from https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=1

Summary of Building Information

The Town provided electricity bill information from FY2018-2019 (July 2018 through June 2019). While all sites had energy charges except the parking lots, not all used enough electricity to qualify for demand charges. To be consistent across all sites, electricity usage and expenditure at the high school did not include net metering credits, even though these were applied in FY2018-2019. Most sites also have diesel generators, though their capabilities are limited and are likely due for replacement in the near term. Table 2 shows the annual electricity usage, peak demand, electricity expenditure, local hosting capacity, generator information, and general existing conditions information for all sites.

Table 2. Existing Conditions at Town Sites

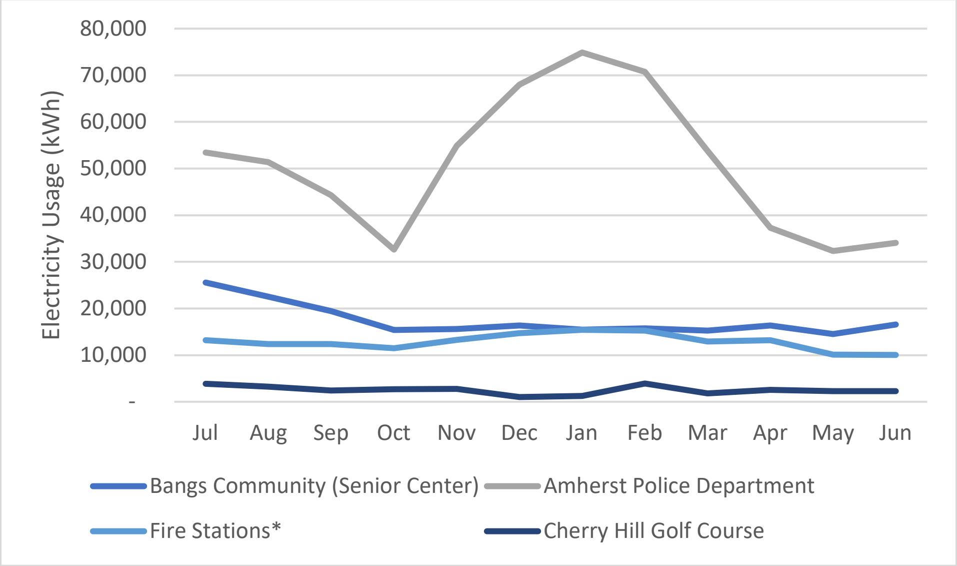
Facility	Annual Electricity Use (kWh)	Annual Peak Demand (kW)	Annual Electricity Spend ($)	$/kWh	Local Hosting Capacity	Diesel Generator Capacity (kW)	Notes
Bangs Community Center	208,680	86	$41,605	$0.1994	>0.5 to 1 MW	-	Two strategic tree removals add significant solar capacity
Amherst Police Department	607,680	133	$90,079	$0.1482	1 to 2 MW	-	
Fire Stations*	154,343	39	$25,462	$0.1650	>0.5 to 1 MW	-	
Crocker Farm Elementary School	316,932	161	$60,100	$0.1896	>0.5 to 1 MW	60 kW at 3-phase	Generator likely installed in 2002 Strategic tree removal may add significant PV capacity to the carport array
Amherst-Pelham Regional High School	1,264,320	419	$224,596	$0.1776	>0.5 to 1 MW	100 kW; 125 kVA; 174 A circuit breaker	Generator installed 3/7/1997
Amherst Regional Middle School	1,039,800	316	$171,192	$0.1646	>0.5 to 1 MW	100 kW at 3-phase; 60kW standby	East generator was installed in 2007
Spring Street Lot	-	-	-	-	>0.5 to 1 MW	-	
Pray Street Lot	-	-	-	-	2 to 3 MW	-	
Boltwood Garage	-	-	-	-	>0.5 to 1 MW	-	
Cherry Hill Golf Course	30,088	-	$7,627	$0.2535	>0.5 to 1 MW	-	
TOTAL	**3,621,843**		**$620,661**	**$0.1854**			

* Note that the data for the North Fire Station combines usage of the Central Fire Station, even though solar feasibility was only performed for the North Fire Station.

During the initial feasibility assessment of the Amherst sites, Cadmus checked existing Eversource electric utility feeder hosting capacity at each property. The local utility feeders need to be able to withstand the potential load increase of the solar PV plus energy storage systems. This preliminary verification of hosting capacity, completed using Eversource's online Hosting Capacity Map, is a critical step for solar PV projects to help ensure projects do not encounter unexpectedly high interconnection costs later in the development timeline. Although the grid's local hosting capacity for most sites is limited to less than 1 MW, it is important to note that hosting capacity is fluid and actively updated by the utility. It will be important to reference back to this map with a potential developer if Amherst's projects progress in the future. [12]

Figure 2 illustrates monthly electricity consumption at Town sites. The Police Department consumes the most electricity in relation to other Town sites, with peak consumption in winter months. The Fire Stations have more consistent usage throughout the year, with highest usage in winter months. In contrast, the Bangs Community Center has highest electricity consumption during summer months, potentially due to cooling. Cherry Hill Golf Course has highest usage in August and February, potentially due to cooling and heating needs.

Figure 2. Monthly Electricity Consumption at Town Sites



* Note that the Fire Stations usage is combined for the North Fire Station and Central Fire Station.

Figure 3 illustrates monthly electricity consumption for school sites. The High School has the greatest overall usage, with most occurring in November, February, and May. The Middle School has the highest usage in July, December, and January. Crocker Farm Elementary School has highest usage in September.

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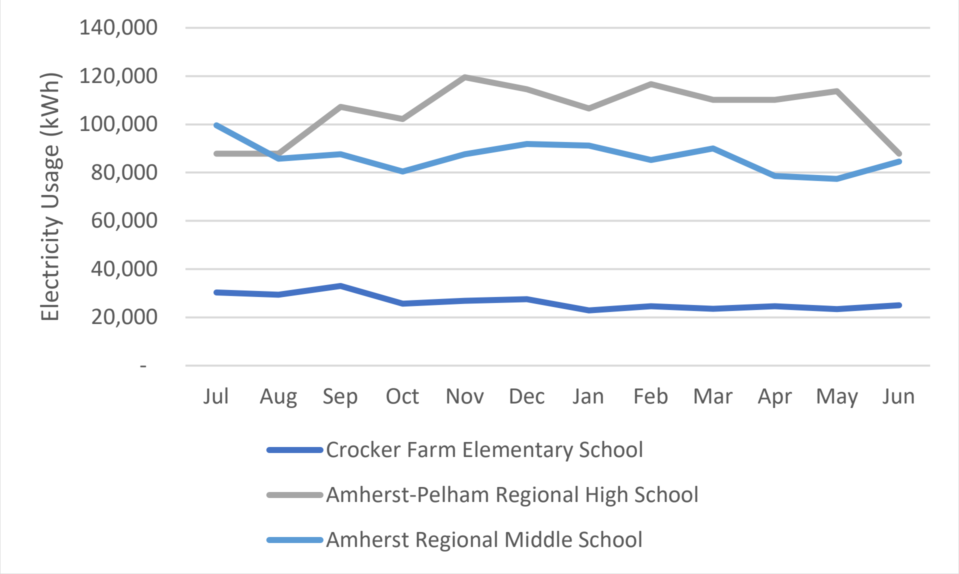
[12] Eversource Hosting Capacity Map, Western Massachusetts. Retrieved from https://eversource.maps.arcgis.com/apps/webappviewer/index.html?id=eea778f65e5d4bac87a7ad83bde9f999

Figure 3. Monthly Electricity Consumption at School Sites



Summary of Solar Feasibility

The specific sites analyzed for solar technical and economic feasibility, and their estimated system capacities and annual production, are listed in Table 3 below. Cadmus modeled 370-Watt PV modules and inverters with a realistic 1.25 DC/AC ratio. The final decision on technology deployed at each site will be made by the developer.

In total, the sites' combined estimated solar PV capacity is at least 3,744 kW-DC, which would be capable of generating at least 4,513,681 kWh of clean electricity annually and offset around 30,000 tons of CO_2 in the 20-year lifecycle.

Table 3. Summary of Solar Feasibility

Site Name	Scenario	PV Capacity (kW-DC)	PV Capacity (kW-AC)	Estimated Year 1 PV Generation (kWh)	Outage Duration	Lifetime Total GHG Reduction (Tons CO2)
Bangs Community Center	Existing conditions	91.7	71.9	105,350	24	1,512
					48	1,514
	Tree removal	129.2	101.2	156,267	24	1,669
					48	1,672
Amherst Police Department	Existing conditions	39.6	31	49,949	24, 50% CLF*	877
					24, 100% CLF*	864
					48, 50% CLF*	865
					48, 100% CLF*	852
North Fire Station	Existing conditions	98.4	77.2	116,823	24	1,273
					48	1,280
Crocker Farm Elementary	Existing conditions	334.4	262.2	403,956	24	2,617
					48	2,650
		378.9	297	457,487	24	2,622

	Tree removal				48	2,662
Amherst-Pelham Regional High School	Existing conditions	1,541.8	1,237	1,875,922	24	11,045
					48	11,490
Amherst Regional Middle School	With ground mount	1,258	1,003.7	1,505,097	24	8,456
					48	9,046
	No ground mount	1,037	823.7	1,249,803	24	8,936
					48	8,991
Spring Street Lot	Existing conditions	86.6	67.9	110,093	-	842
Pray Street Lot	Existing conditions	99.9	78.3	117,233	-	849
Boltwood Garage	Existing conditions	180.2	141.2	213,332	-	1,673
Cherry Hill Golf Course	Existing conditions	13.3	10.4	15,926	-	122
	TOTAL (min)	**3,523**	**2,801**	**4,258,387**	-	**29,241**
	TOTAL (max)	**3,826**	**3,045**	**4,618,129**	-	**30,513**

* CLF: Critical load factor, the percentage of load to be met during an outage

Summary of Storage Feasibility

Cadmus combined several sources of information to perform a battery storage feasibility analysis. This information included electricity bills, solar PV capacities, and technology cost assumptions. Cadmus's energy storage analysis utilizes the NREL REopt toolset, which optimizes renewable generation and storage capacities based on building load profiles, resilience, and financial savings. [13]

Battery energy storage systems provide financial benefits to many sites. The primary revenue streams for ESS are the ConnectedSolutions program, the SMART program ESS adder, and Clean Peak program.

Based on discussions with the Town, Cadmus modeled at least two outage scenarios for each site: 24 hours and 48 hours. To best simulate a worst-case scenario, the outage dates were selected based on the peak demand of the year for each site. The Middle School and High School both had 15-minute interval data, while all other sites were estimated using a Department of Energy typical load shape that best fit the peak demand identified in electric bills.[14] Depending on model results and other considerations, some sites have additional ESS scenarios, such as with or without tree removal, adjusted critical load factors, or with or without a ground mount PV system. The parking lots were not included in the analysis because they don't have on-site load. Cherry Hill Golf Course was not included due to the small solar PV size, minimal electricity usage, and lack of suitability for emergency use scenarios.

Battery energy capacity costs ($/kWh) and power capacity costs ($/kW) were estimated based on the percent difference between solar installation costs in Massachusetts and the NREL assumption—approximately 45% higher than the NREL default. Adjusting for these Massachusetts-specific soft costs,

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[13] NREL REopt Lite Web Tool. Retrieved from https://reopt.nrel.gov/

[14] Department of Energy. Commercial Reference Buildings. Retrieved from https://www.energy.gov/eere/buildings/commercial-reference-buildings

Cadmus used $582/kWh and $1163/kW for ESS modeling. More details are available in Appendix A. Site Analyses. Information on inputs used in ESS modeling are listed below.

- **Solar Incentive Payment ($/kWh)**. The solar incentive payment is calculated using the SMART program's Value of Energy Workbook (see more information on inputs in Appendix B. SMART Program Information). For sites with multiple array types (e.g., building, carport), a combined solar incentive payment was calculated by weighting by proportion of DC capacity.
- **PV Capital Cost ($/kW-DC)**. Solar capital costs were estimated using the Massachusetts DOER's Qualified Units List, which has data on solar project sizes and costs in the State.[15]
- **Load Profile**. The load profile (kW demand in hourly intervals for a year) is a foundational input for the ESS sizing. For sites where actual interval data was unavailable, one of 16 load profiles from DOE Commercial Reference Building (CRB) models was be used.
- **Minimum ESS Power (kW)**. To qualify for the SMART energy storage adder, a facility's ESS power must be at least 25% of the facility's solar capacity. In addition, most sites had higher maximum demand values that the minimum ESS power as required by SMART, so the minimum ESS power was the higher of the two.
- **Critical Load Factor**. The critical load is the load of the facility that must be met during an outage. For sites designated as emergency shelters, a critical load factor greater than 100% is recommended. For sites with ESS not used primarily for resilience, as critical load factor of 50% can be used as a standard estimate.
- **Outage Start Date/Time**. The outage start date and time were selected based on the timing of the peak annual demand for each site, either identified in interval data for the Middle and High School, or from estimated load profiles for all other sites.

A summary of background assumptions and inputs for each scenario are shown below in Table 4.

Table 4. Battery Energy Storage System Assumptions and Inputs

Site Name	Scenario	Solar Incentive Payment ($/kWh)	PV Capital Cost ($/kW-DC)	Load Profile	Minimum ESS Power (kW)	Critical Load Factor	Outage Start Date/Time
Bangs Community Center	Existing Conditions	$0.1812	$2747	School-secondary	40	110%	June 8 2AM
	Tree Removal	$0.1601	$2744	School-secondary	40	110%	June 8 2AM
Amherst Police Department	Existing Conditions	$0.2136	$3314	Office- large	40	100%, 50%*	April 3 2AM
North Fire Station	Existing Conditions	$0.1411	$2626	Office- large	25	100%	Nov 2 2AM
Crocker Farm Elementary School	Existing Conditions	$0.1334	$2351	School-primary	100	100%	June 8 2AM
	Tree Removal	$0.1353	$2441	School-primary	100	100%	June 8 2AM
Regional High School	Existing Conditions	$0.1062	$1989	Interval Data	385	100%	May 16 2AM
Regional Middle School	Without ground mount	$0.1033	$1993	Interval Data	259	100%	Sep 6 2AM

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[15] Massachusetts Department of Energy Resources, Lists of Qualified Generation Units. Retrieved from https://www.mass.gov/service-details/lists-of-qualified-generation-units

	With ground mount	$0.1034	$2014	Interval Data	315	100%	Sep 6 2AM

* A critical load factor of 50% was added as an option for the Amherst Police Department due to the significant cost of a battery sized for 100%.

Table 5 shows a summary of ESS analysis results. The ESS power (kW) is based on the peak demand of the site, and the ESS capacity (kWh) is related to the power and outage duration.

Table 5. Summary of Battery Energy Storage System Feasibility

Site Name	Scenario	Solar PV Potential (kW-DC)	Outage Duration (hours)	Critical Load Factor	ESS Potential (kW / kWh)
Bangs Community Center	Existing Conditions	92	24	110%	70 / 668
			48	110%	70 / 739
	Tree Removal	129	24	110%	64 / 462
			28	110%	64 / 513
Amherst Police Department	Existing Conditions	40	24	50%	64 / 1045
				100%	132 / 2319
			48	50%	64 / 2120
				100%	132 / 4583
North Fire Station	Existing Conditions	98	24	100%	35 / 492
			48	100%	35 / 591
Crocker Farm Elementary School	Existing Conditions	334	24	100%	100 / 419
			48	100%	100 / 466
	Tree Removal	379	24	100%	100 / 384
			48	100%	100 / 431
Regional High School	Existing Conditions	1542	24	100%	385 / 2736
			48	100%	385 / 3632
Regional Middle School	Without ground mount	1037	24	100%	259 / 2183
			48	100%	259 / 2760
	With ground mount	1258	24	100%	315 / 1012
			48	100%	315 / 1432

The largest batteries (kW) are required at the High School, Middle School, Police Department, and Crocker Farm Elementary School, as these facilities have the highest peak demands. Longer outages require greater battery capacities (kWh), so all 48-hour outage scenarios involve higher battery capacities. Determining the necessary critical load factor for each site directly affects the ESS sizing; not all sites may require 100% of load being met, and lower critical load will result in a smaller battery.

Summary of Financial Feasibility

The objective of the financial optimization is to minimize life cycle cost (and therefore maximize NPV). The life cycle cost is the present value of costs, after taxes and incentives associated with each case. Cadmus used a typical life cycle of 20 years of the analysis, which includes equipment O&M cost escalation assumptions, battery replacement at year 10, and declining solar PV generation. While REopt reports payback period and Internal Rate of Return (IRR) as well, the optimization does not maximize these metrics. REopt maximizes NPV, and IRR and payback period are simply calculated for the system that maximizes NPV. The developer will determine the PPA rates they are willing to offer the Town at each facility. All modeling results have project owner IRRs of 8.3%, which falls within the 7% to 15% range developers require to consider a project.

More details on financial analysis inputs is available in Appendix A. Site Analyses. Descriptions of key financial analysis outputs are provided below.

- **Payback Period (years)**. The payback period expected for the project owner to recoup its capital investment, ideally less than 10 years.
- **Lifetime NPV Savings ($)**
    - **Demand Response**. Demand response revenue was calculated based on the participation type (daily or targeted dispatch), average demand reduced per event, and expected number of events participated in. The daily program participation option from ConnectedSolutions offers the greatest financial return, so these are the estimates included in the memo body, though estimates for targeted program participation are included in Appendix D. These savings were calculated for 10 years, with more detail available in Appendix D. ConnectedSolutions Program Information.
    - **Clean Peak Standard**. Clean Peak Energy Certificate (CPEC) revenue was calculated based on the timing of modeled ESS dispatch to onsite load over the course of the year in coincidence with Clean Peak Periods. CPEC revenue was modeled for 2023 to 2035, which is the maximum time horizon currently available for the program. More information on CPEC calculations is shown in Appendix C. Clean Peak Standard Program Information.
    - **Base**. Base lifetime savings are the results from the REopt model, which include ownership models, economic incentives, and tax policies. REopt offers detailed information on its economic model assumptions and structure in its user manual.[16]
    - **Combined**. The combined lifetime NPV savings are the total estimated NPV lifetime savings relative to business as usual, which includes the base output from REopt plus the estimated revenue from participation in demand response (ConnectedSolutions), and the Clean Peak Standard program. A NPV discount rate of 5.64% is used.

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[16] REopt Lite User Manual. Retrieved from https://reopt.nrel.gov/tool/REopt%20Lite%20Web%20Tool%20User%20Manual.pdf#page=5

A summary of financial modeling results is shown in Table 6. If a site has multiple scenarios, the optimal scenario from a financial standpoint is highlighted in green.

Table 6. Summary of Financial Feasibility

Site	Scenario	Outage Duration (hours)	Payback Period (years)	Lifetime NPV Savings ($)			
				Demand Response	Clean Peak	Base	Total
Bangs Community Center	Existing Conditions	24	9.6	$47,025	$5,688	$(82,645)	$(29,931)
		48	9.6		$5,862	$(129,832)	$(76,945)
	Tree Removal	24	9.3	$42,995	$7,397	$106,968	$157,360
		48	9.4		$6,245	$73,550	$122,790
Amherst Police Department	Existing Conditions, 50% CLF	24	9.8	$42,995	$2,605.69	$(465,377)	$(419,777)
		48	9.9		$3,421.53	$(1,196,789)	$(1,150,373)
	Existing Conditions, 100% CLF	24	9.9	$88,676	$3,461	$(1,429,208)	$(1,337,070)
		48	10		$3,556	$(2,989,114)	$(2,896,882)
North Fire Station	Existing Conditions	24	9.5	$23,513	$4,288.13	$(164,368)	$(136,567)
		48	9.5		$4,452.96	$(229,244)	$(201,278)
Crocker Farm Elementary School	Existing Conditions	24	8.4	$67,179	$13,504.99	$425,684	$506,368
		48	8.4		$11,081.29	$399,446	$477,706
	Tree Removal	24	8.4		$10,058.87	$514,628	$591,866
		48	8.4		$10,715.07	$490,076	$567,970
Amherst-Pelham Regional High School	Existing Conditions	24	8.4	$209,002	$40,577.46	$710,869	$960,448
		48	8.3		$41,543.99	$233,982	$484,528
Amherst Regional Middle School	Without ground mount	24	8.3	$203,030	$18,116.12	$554,532	$775,678
		48	8.3		$29,399.90	$152,841	$385,271
	With ground mount	24	8.4		$11,008.45	$2,662,496	$2,876,535
		48	8.3		$15,636.16	$2,560,131	$2,778,797
Spring Street Lot	Existing conditions	-	8.8	-	-	$28,214	$28,214
Pray Street Lot	Existing conditions	-	8.8	-	-	$5,287	$5,287
Boltwood Garage	Existing conditions	-	8.8	-	-	$31,241	$31,241
Cherry Hill Golf Course	Existing conditions	-	7	-	-	$505	$505
						TOTAL (min)	($1,762,353)
						TOTAL (max)	$4,095,112

Note: red text indicates that the scenario results in overall negative NPV to the Town over the lifetime of the project, relative to business as usual.

Recommendations

The ten sites evaluated in this report use an estimated 3,621,843 kWh of electricity each year, costing the Town more than $620,000 annually. As detailed in this report, the sites have the potential to host up to 3,826 kW-DC of new solar PV capacity, enough to generate an estimated 4,618,129 kWh of clean electricity annually and offset 128% of on-site electricity demand at these facilities. Battery storage offers additional benefits for many sites, with batteries sized for 24-hour outages offerings the optimal lifetime NPV savings relative to business as usual.

This analysis and the recommended next steps are intended to help the Town develop an actionable path forward, prioritizing the most technically and financially feasible options for procuring renewable energy resources and reducing carbon emissions. Recommended immediate next steps are outlined below:

1. **Present and discuss report findings with Town stakeholders.**
   A crucial first step is to share report findings with Town stakeholders, which can initiate productive conversations on how to proceed with renewable energy and battery storage procurement on Town properties.

2. **Refine objectives for each site, especially in terms of battery storage.**
   For sites with limited solar potential and high on-site usage, especially the Police Department, installation of solar paired with storage may present significant negative lifetime NPV relative to business as usual. The Town can consider doing a more detailed feasibility analysis on these sites to get a clearer idea of options.

3. **If moving forward with procurement, consider bulk RFP procurement rounds.**
   By using a series of bulk RFP procurement rounds, the Town can take advantage of economies of scale to further increase lifetime NPV savings. By allowing developers to bid on the total installed capacity of all sites at once, developers can lower administrative, installation, and O&M costs. This approach may allow developers to bid on smaller projects that are less financially viable on their own, like the Police Department and Cherry Hill Golf Course.

This assessment is intended to be used as a resource and tool for the Town to make informed decisions about which projects and configurations to pursue, as well as to serve as a point of reference when reviewing developer responses to a future Request for Proposal (RFP). Ultimately, the solar PV and BESS designs, and prices offered, will be determined by the responding developers.

Appendix A. Site Analyses

This section includes detailed information for each site on solar PV, ESS, and financial analysis results.

A summary of REopt modeling assumptions is shown below.

Table 7. REopt Modeling Assumptions

Assumption	Estimated Value
Third-party Owner Effective Tax Rate*	27.32%
Electricity Cost Escalation Rate	1.9%
Host and Third-Party Owner Discount Rates	5.64%
Project Lifetime (years)	20
Host Effective Tax Rate	0%
O&M Cost Escalation Rate	2.5%
SMART Capacity Block	11
PV Annual O&M Cost ($/kW-DC)	$17
PV MACRS schedule	5 years
PV MACRS bonus depreciation	100%
BESS Energy Capacity Cost ($/kWh)**	$582
BESS Power Capacity Cost ($/kW)**	$1,163
BESS Energy Capacity Replacement Cost ($/kWh)	$220
BESS Energy Capacity Replacement Year	10
BESS Power Capacity Replacement Cost ($/kW)	$440
BESS Power Capacity Replacement Year	10
BESS total AC-AC round trip efficiency	89.9%
BESS Minimum state of charge	20%
BESS Initial state of charge	50%
BESS MACRS schedule	7 years
BESS MACRS bonus depreciation	100%
BESS Clean Peak Standard Seasonal Multiplier	varies
BESS Clean Peak Standard Resilience Multiplier (1.5)	1.5
BESS Clean Peak Standard SMART ES	0.3
BESS Clean Peak Standard Years of Participation	2023 to 2035

* The third-party owner effective tax rate represents the federal and Massachusetts effective tax rates.

** The ESS energy and power capacity costs are based on NREL's defaults ($388/kWh and $755/kW) adjusted to reflect the higher installation soft costs in Massachusetts. A factor of 1.5 was calculated based on the difference in Massachusetts PV installation costs ($/kW-AC) and NREL default PV installation costs. PV installation costs were obtained from the List of SMART Qualified Generation Units, with more details available in the Appendix.[17]

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[17] Massachusetts Department of Energy Resources, Lists of Qualified Generation Units. Retrieved from https://www.mass.gov/service-details/lists-of-qualified-generation-units

Bangs Community Center

The Bangs Community Center has the capacity to support a solar PV installation between 92 and 129 kW-DC. An array of these capacities would generate approximately 105,350 and 156,267 kWh annually, enough to offset up to 50% to 75% of the site's annual electricity usage. Strategic tree removal may offer significant financial benefits by reducing the battery size required to meet 110% of on-site load during outage scenarios. With more electricity from solar available to meet on-site demand, the battery is also able to generate more revenue from participation in demand response programs like ConnectedSolutions and the Clean Peak Program, further improving the financial feasibility.

Table 8. Bangs Community Center Site Summary

Metric	Value	
	Existing Conditions	Tree Removal
DC Capacity (kW)	91.7	129.2
AC Capacity (kW)	72	101
No. Modules	248	349
Est. Year 1 PV Generation (kWh)	105,350	156,267
On-Site Load Offset by PV Generation	50.5%	74.9%
Installation Cost ($/kW-DC)	$2747	$2744
Total Installation Cost ($)	$251,899	$354,476
ESS kW / kWh, 24-hour	70 / 668	64 / 462
ESS kW / kWh, 48-hour	70 / 739	64 / 513
Base Lifetime Savings, 24-hour ($)	$(82,645)	$106,968
Base Lifetime Savings, 48-hour ($)	$(129,832)	$73,550

Note: red text indicates that the scenario results in overall negative NPV to the Town over the lifetime of the project, relative to business as usual.

Bangs Carport, Existing Conditions

Bangs Roof, Existing Conditions

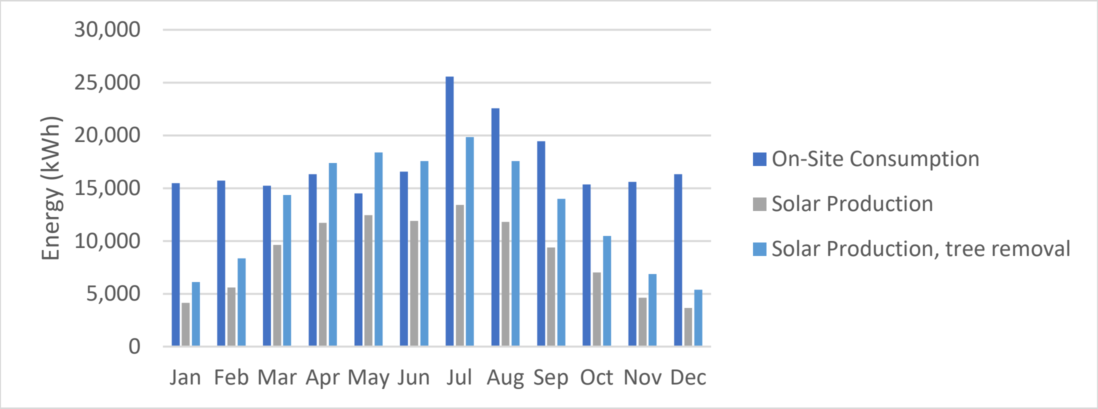
Bangs Carport, strategic tree removal

Bangs Roof, strategic tree removal

Note that red X's indicate suggested strategic trees to remove.

As shown in Figure 4 below, onsite consumption is estimated to exceed solar generation for all months with the existing site conditions. With strategic tree removal, solar generation is estimated to exceed onsite consumption for April, May, and June. This is an example where virtually net metering from the parking lot sites may be prudent.

Figure 4. Estimated Annual Solar Production vs On-Site Consumption at the Bangs Community Center



The figures below display solar PV and ESS performance during the 48-hour outage scenarios. With a larger solar array in the tree removal scenario, the PV is able to recharge the battery faster than with a small solar array.

Figure 5. 48-hour Outage System Performance, Bangs Community Center Existing Conditions

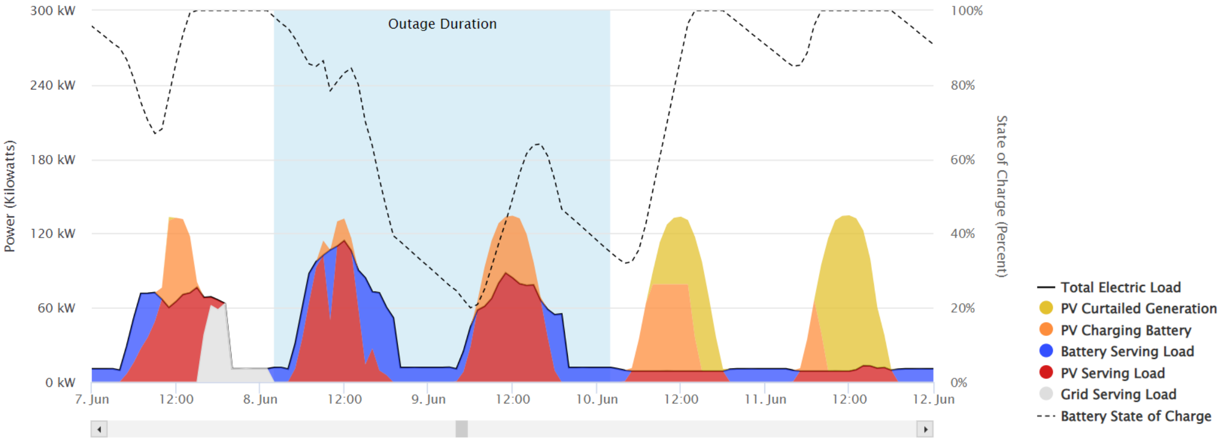
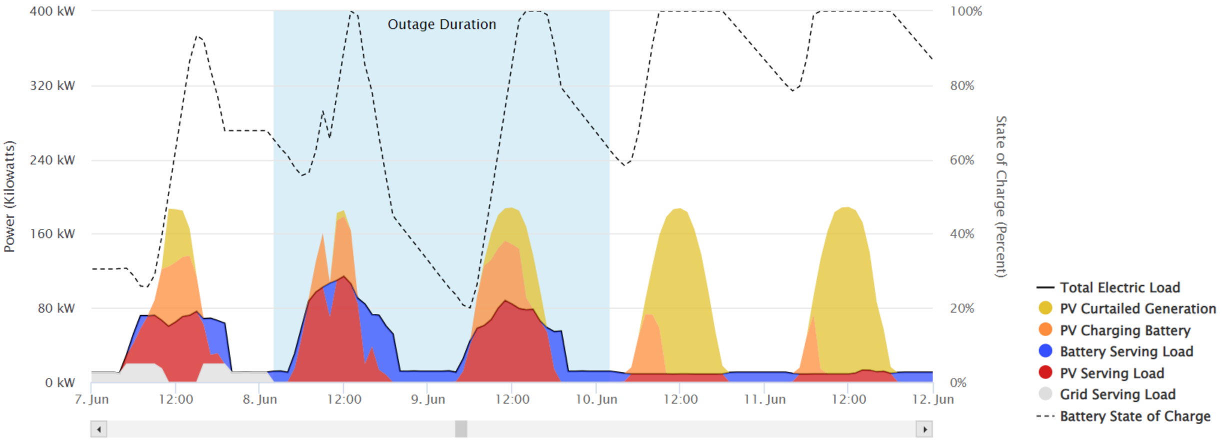


Figure 6. 48-hour Outage System Performance, Bangs Community Center Tree Removal



Amherst Police Department

The Amherst Police Department has the capacity to support a solar PV installation estimated at 40 kW-DC. An array of this capacity would generate approximately 49,950 kWh annually, enough to offset 8.2% of the site's annual electricity usage. Due to the significant on-site usage that is not met by solar production, large batteries are required for all outage scenarios. Though these project financials result in negative lifetime NPV relative to business as usual, the Town can consider the intangible value of resiliency from energy storage at a critical facility like a police department.

Table 9. Amherst Police Department Site Summary

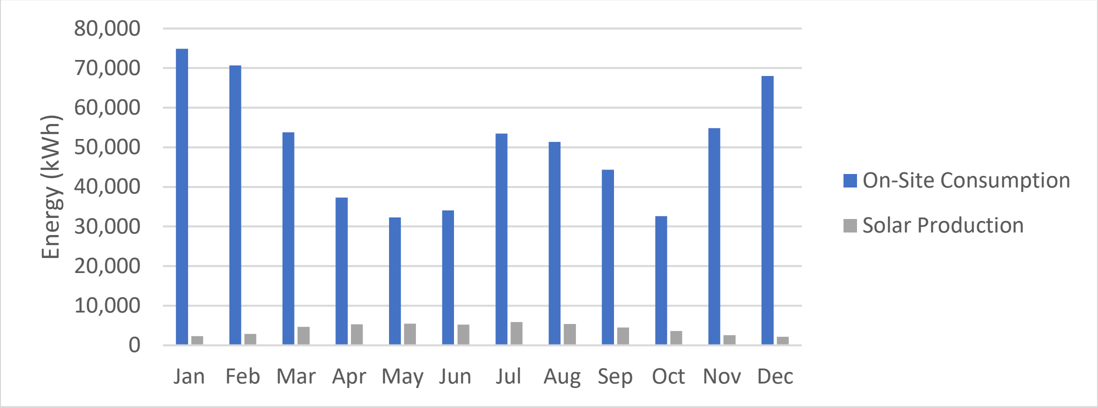
Metric	Value	
	100% CLF*	50% CLF*
DC Capacity (kW)	39.6	
AC Capacity (kW)	31	
No. Modules	107	
Est. Year 1 PV Generation (kWh)	49,950	
On-Site Load Offset by PV Generation	8.2%	
Installation Cost ($/kW-DC)	$3314	
Total Installation Cost ($)	$131,223	
ESS kW / kWh, 24-hour	132 / 2319	64 / 1045
ESS kW / kWh, 48-hour	132 / 4583	64 / 2120
Base Lifetime Savings, 24-hour ($)	$(1,429,208)	$(465,377)
Base Lifetime Savings, 48-hour ($)	$(2,898,114)	$(1,196,798)

* CLF: Critical load factor, the percentage of load to be met during an outage

Note: red text indicates that the scenario results in overall negative NPV to the Town over the lifetime of the project, relative to business as usual.

As shown in Figure 7 below, the Amherst Police Department has significantly higher on-site consumption than solar production. This is an example where virtually net metering from one of the parking lot arrays may be prudent.

Figure 7. Estimated Annual Solar Production vs On-Site Consumption at the Amherst Police Department



The figures below display solar PV and ESS performance during the 48-hour outage scenarios. The small PV array can only offset a limited amount of load during the outage, which is why a large battery is required. With a lower critical load factor (i.e., percentage of load to be met during an outage), a smaller battery is required, which improves the financial feasibility.

Figure 8. 48-hour Outage System Performance, Amherst Police Department 100% Critical Load Factor

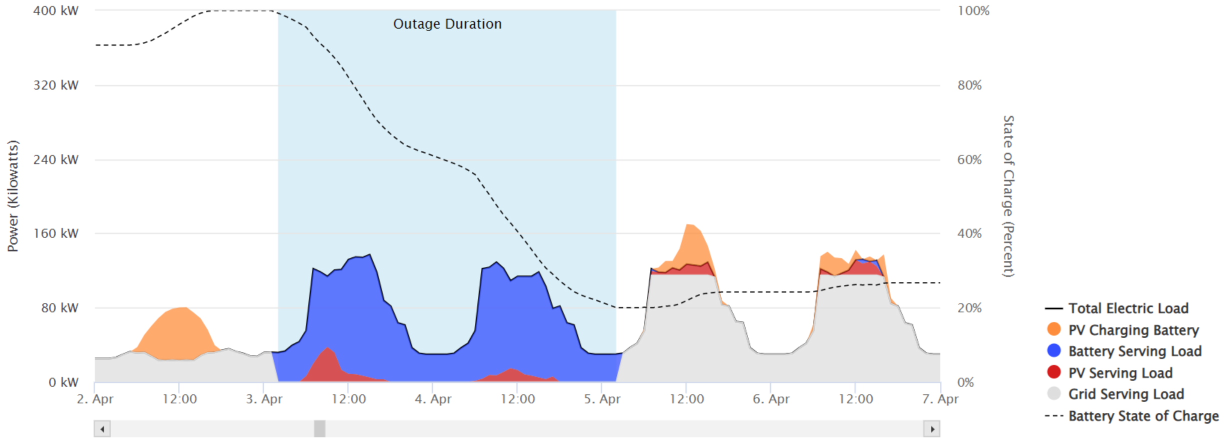
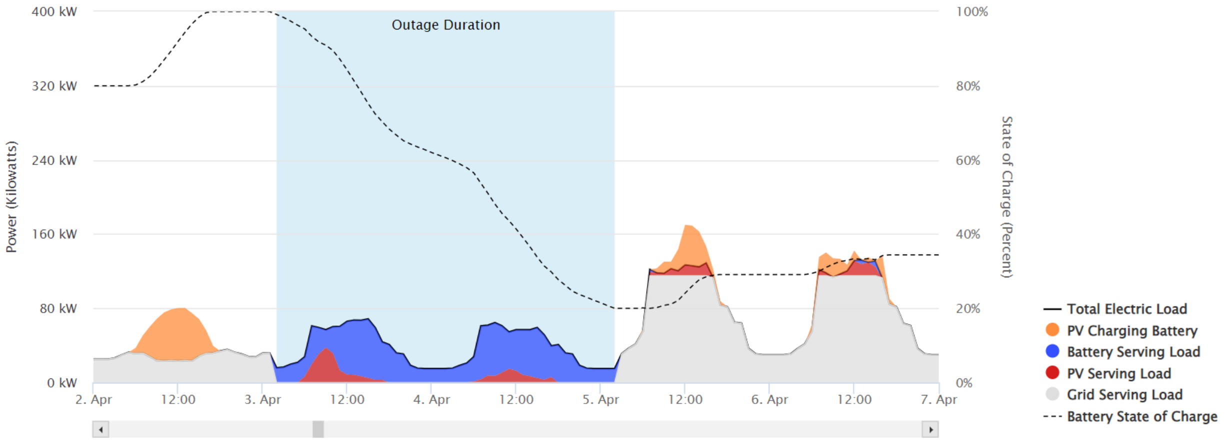


Figure 9. 48-hour Outage System Performance, Amherst Police Department 50% Critical Load Factor



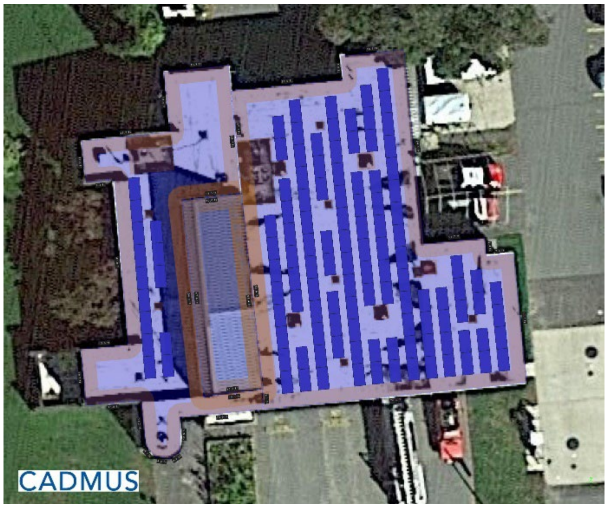
North Fire Station

The North Fire Station has the capacity to support a solar PV installation estimated at 98 kW-DC. An array of this capacity would generate approximately 116,823 kWh annually, enough to offset 76% of both fire station's (North and Central) annual electricity usage. The upfront cost of installing a relatively large battery is the likely cause of negative lifetime NPV for both outage scenarios. Though these project financials result in negative lifetime NPV relative to business as usual, the Town can consider the intangible value of resiliency from energy storage at a critical facility like a fire station.

Table 10. North Fire Station Site Summary

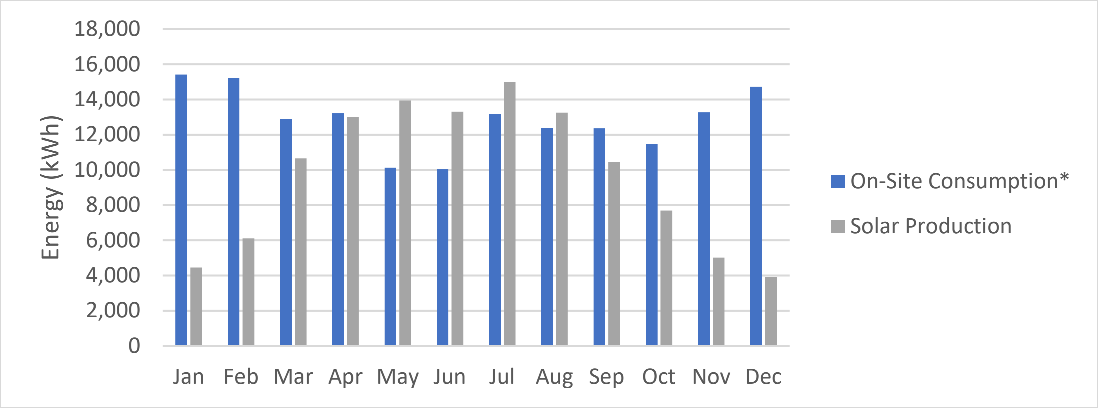
Metric	Value
DC Capacity (kW)	98.4
AC Capacity (kW)	77
No. Modules	266
Est. Year 1 PV Generation (kWh)	116,823
On-Site Load Offset by PV Generation	75.7%
Installation Cost ($/kW-DC)	$2626
Total Installation Cost ($)	$258,393
ESS kW / kWh, 24-hour	35 / 492
ESS kW / kWh, 48-hour	35 / 591
Base Lifetime Savings, 24-hour ($)	$(164,368)
Base Lifetime Savings, 48-hour ($)	$(229,244)

Note: red text indicates that the scenario results in overall negative NPV to the Town over the lifetime of the project, relative to business as usual.



As shown in the figure below, solar production at the North Fire Station offsets the combined consumption of both fire stations for nearly 5 months of the year.

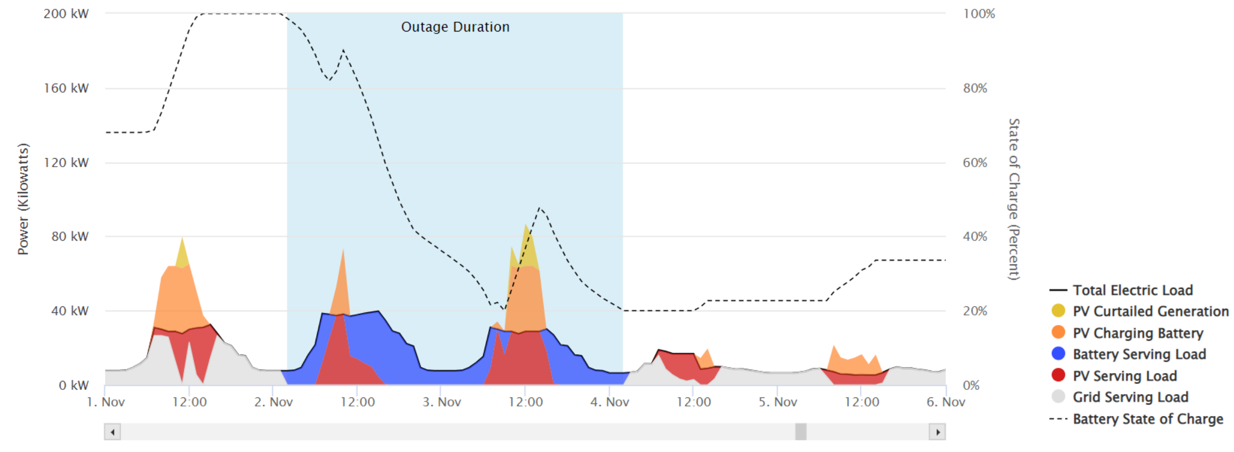
Figure 10. Estimated Annual Solar Production at the North Fire Station vs On-Site Consumption at both fire stations



* Note that on-site consumption is the combined consumption at both Town fire stations.

The figure below displays solar PV and ESS performance during the 48-hour outage scenario.

Figure 11. 48-hour Outage System Performance, North Fire Station



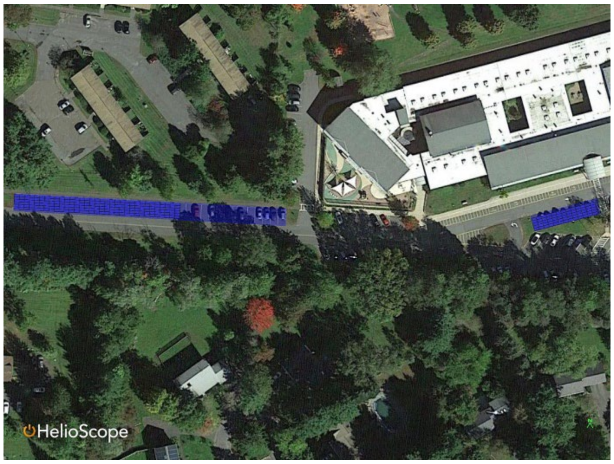
Crocker Farm Elementary School

The Crocker Farm Elementary School has the capacity to support a solar PV installation estimated between 334 to 379 kW-DC. An array of this capacity would generate approximately 403,956 kWh to 457,487 kWh annually, enough to offset 128% to 145% of the site's annual electricity usage.

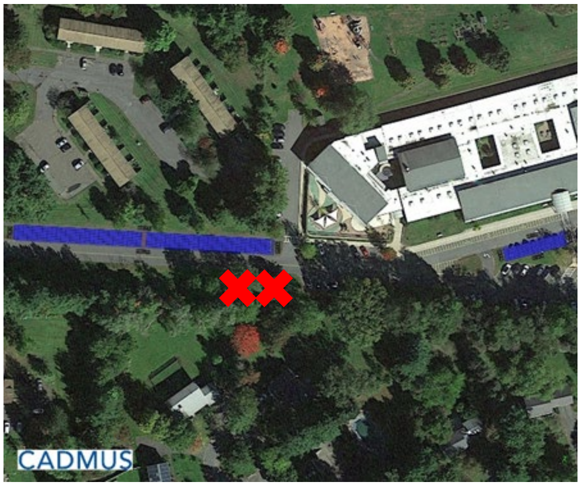
Table 11. Crocker Farm Elementary School Site Summary

Metric	Value	
	Existing Conditions	Tree Removal
DC Capacity (kW)	334	379
AC Capacity (kW)	262	297
No. Modules	904	107
Est. Year 1 PV Generation (kWh)	403,956	457,487
On-Site Load Offset by PV Generation	128%	145%
Installation Cost ($/kW-DC)	$2351	$2441
Total Installation Cost ($)	$786,088	$924,802
ESS kW / kWh, 24-hour	100 / 419	100 / 384
ESS kW / kWh, 48-hour	100 / 466	100 / 431
Base Lifetime Savings, 24-hour ($)	$425,684	$514,628
Base Lifetime Savings, 48-hour ($)	$399,446	$490,076

Crocker Farm Elementary Roof



Crocker Farm Elementary Carport, existing conditions

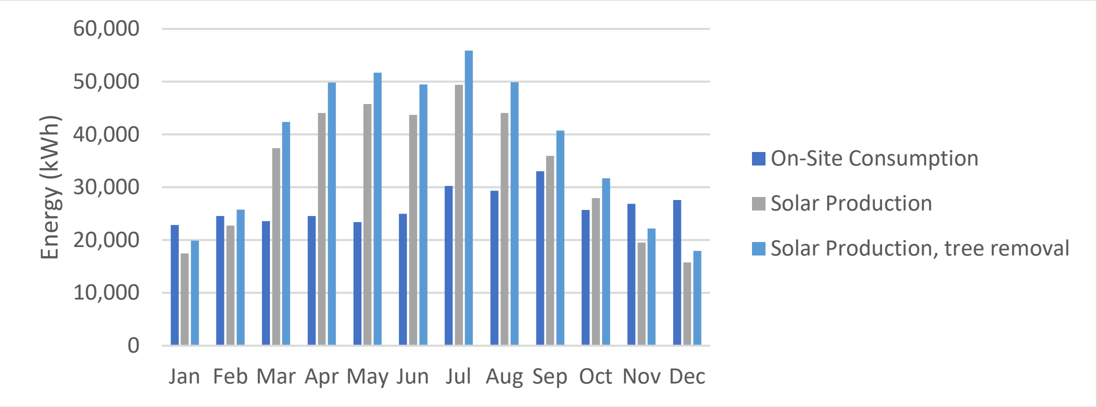


Crocker Farm Elementary Carport, strategic tree removal

Note that red X's indicate suggested strategic trees to remove.

As shown in the figure below, solar production in either scenario has the potential to offset a significant portion of on-site consumption. Excess production can be virtually net metered to other Town sites that lack local generation.

Figure 12. Estimated Annual Solar Production vs On-Site Consumption at Crocker Farm Elementary School



The figures below display solar PV and ESS performance during the 48-hour outage scenarios.

Figure 13. 48-hour Outage System Performance, Crocker Farm Elementary School, Existing Conditions

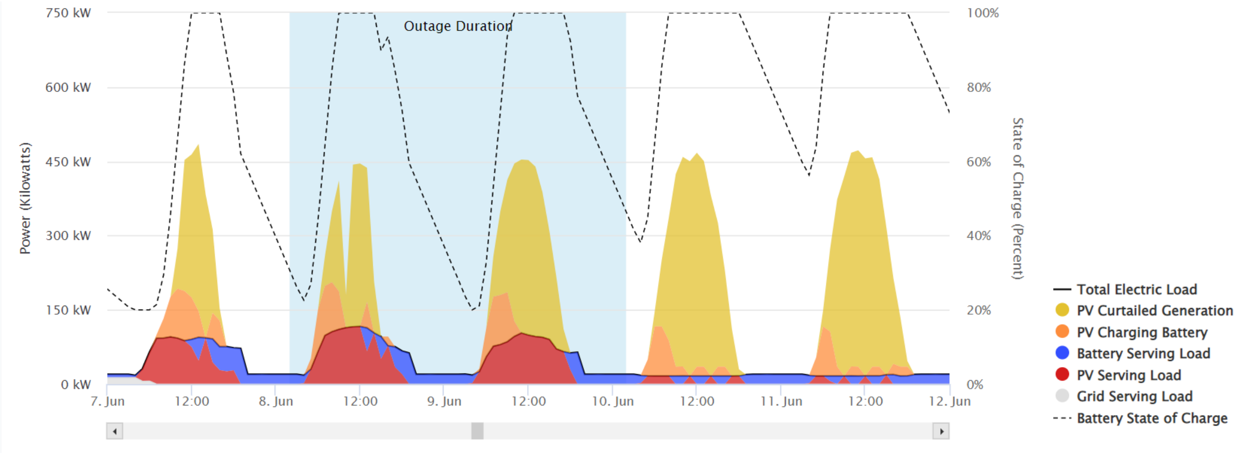
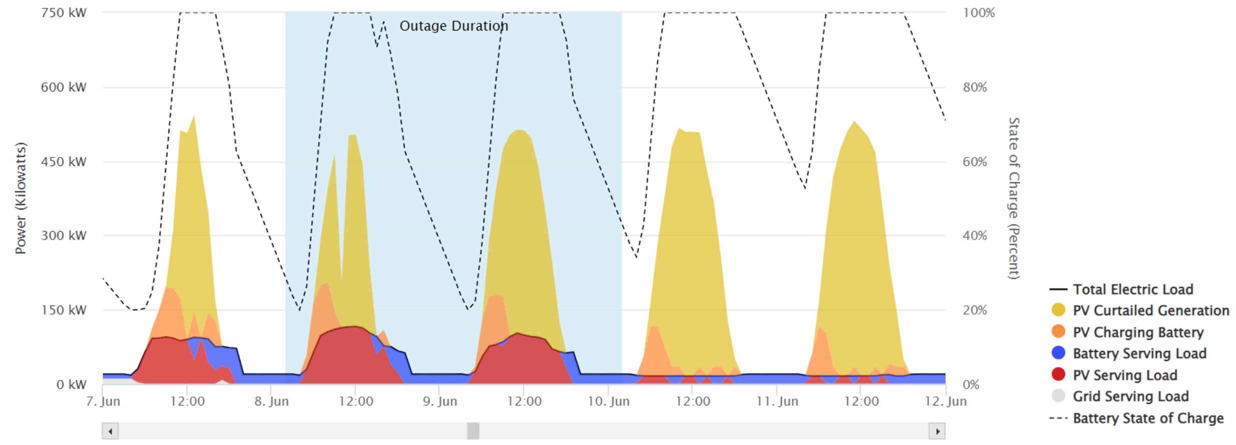


Figure 14. 48-hour Outage System Performance, Crocker Farm Elementary School, Tree Removal



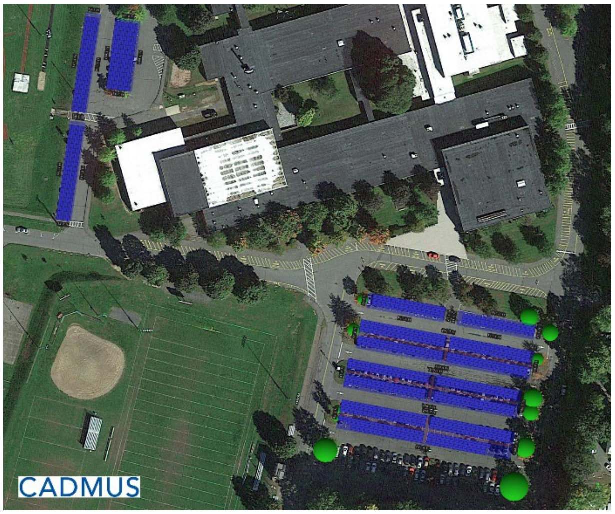
Amherst-Pelham Regional High School

The Amherst-Pelham Regional High School has the capacity to support a solar PV installation estimated at 1542 kW-DC. An array of this capacity would generate approximately 1,875,923 kWh annually, enough to offset 148% of the site's annual electricity usage.

Table 12. Amherst-Pelham Regional High School Site Summary

Metric	Value
DC Capacity (kW)	1541.8
AC Capacity (kW)	1237
No. Modules	4167
Est. Year 1 PV Generation (kWh)	1,875,923
On-Site Load Offset by PV Generation	148%
Installation Cost ($/kW-DC)	$1989
Total Installation Cost ($)	$3,067,139
ESS kW / kWh, 24-hour	385 / 2736
ESS kW / kWh, 48-hour	385 / 3632
Base Lifetime Savings, 24-hour ($)	$710,869
Base Lifetime Savings, 48-hour ($)	$233,982

The large tree between rooftop arrays in the southeast quadrant is planned from remove in the next year, so modules were placed assuming the tree would no longer be there.

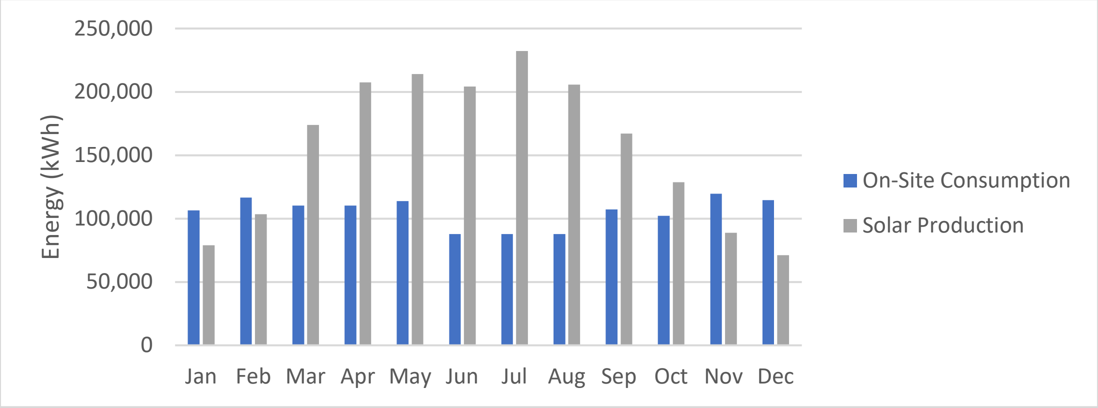


High School Carports

High School Roof

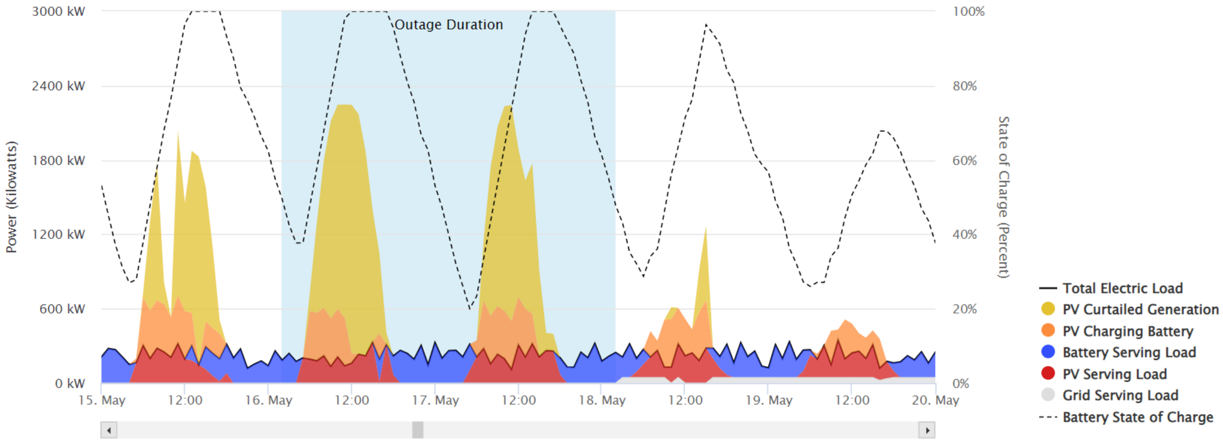
As shown in Figure 15 below, the significant PV potential can offset on-site consumption nearly every month. The excess generation offered by the array can be virtually net metered to other Town sites lacking sufficient on-site generation, such as the Police Department.

Figure 15. Estimated Annual Solar Production vs On-Site Consumption at Amherst-Pelham Regional High School



The figure below displays solar PV and ESS performance during the 48-hour outage scenario.

Figure 16. 48-hour Outage System Performance, Amherst-Pelham Regional High School



Amherst Regional Middle School

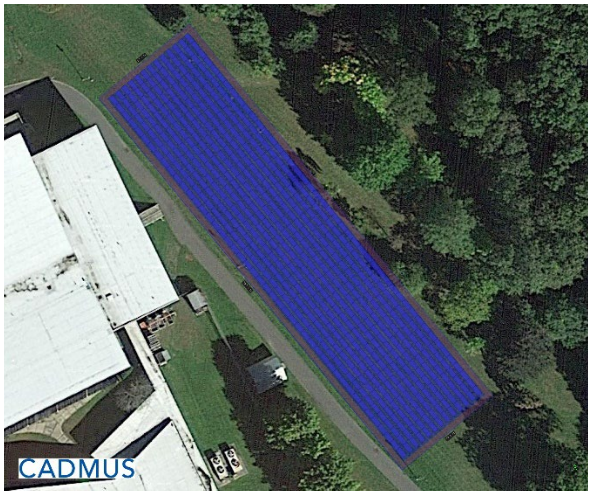
The Amherst Regional Middle School has the capacity to support a solar PV installation estimated at 1037 kW-DC (roof + carport) or 1258 kW-DC (roof + carport + ground mount). An array of this capacity would generate approximately 1,249,803 kWh or 1,505,097 kWh annually, enough to offset between 120% and 145% of the site's annual electricity usage.

Table 13. Amherst Regional Middle School Site Summary

Amherst Regional Middle School System Details		
	With Ground Mount	Without Ground Mount
DC Capacity (kW)	1,258	1,036.7
AC Capacity (kW)	1003.7	823.7
No. Modules	3,961	3,363
Est. Year 1 PV Generation (kWh)	1,505,097	1,249,803
On-Site Load Offset by PV Generation	145%	120%
Installation Cost ($/kW-DC)	$2,014	$1,993
Total Installation Cost ($)	$2,533,066.31	$2,066,411.24
ESS kW / kWh, 24-hour	315 / 1012	259 / 2183
ESS kW / kWh, 48-hour	315 / 1432	259 / 2760
Base Lifetime Savings, 24-hour ($)	$2,662,496	$554,532
Base Lifetime Savings, 48-hour ($)	$2,560,131	$152,841

Middle School Roof

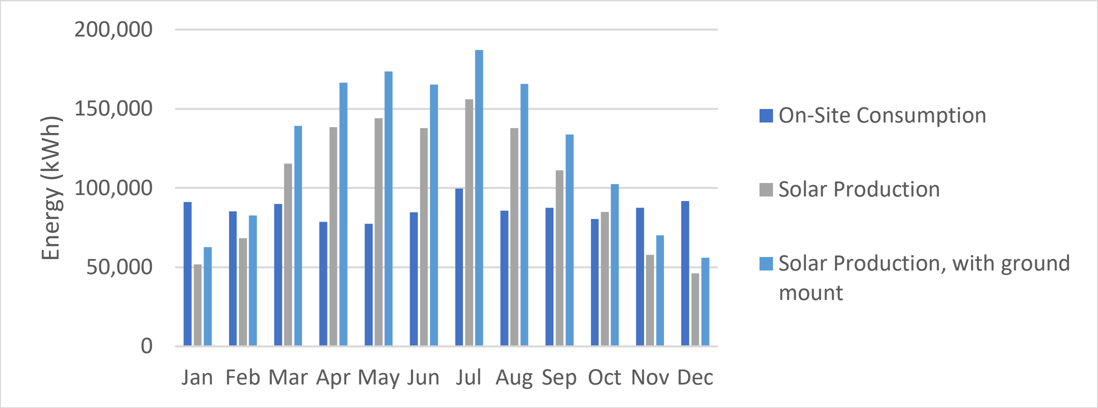
Middle School Carports



Middle School Ground Mount

As shown in Figure below, estimated solar generation exceeds on-site consumption nearly every month, with and without the ground mount option. Excess generation can be virtually net metered to other Town properties without existing onsite generation.

Figure 17. Estimated Annual Solar Production vs On-Site Consumption at Amherst Regional Middle School



The figures below display solar PV and ESS performance during the 48-hour outage scenarios.

Figure 18. 48-hour Outage System Performance, Amherst Regional Middle School, without ground mount

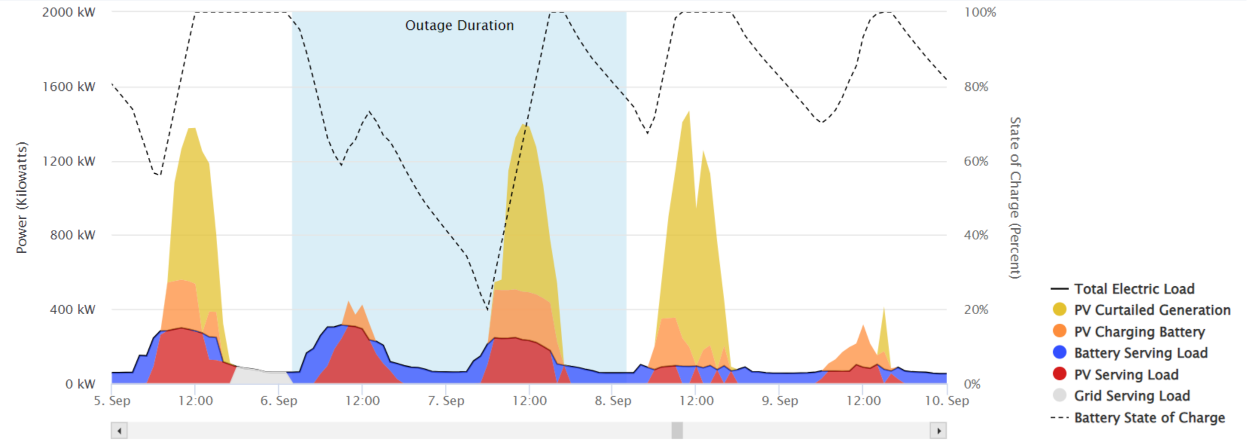
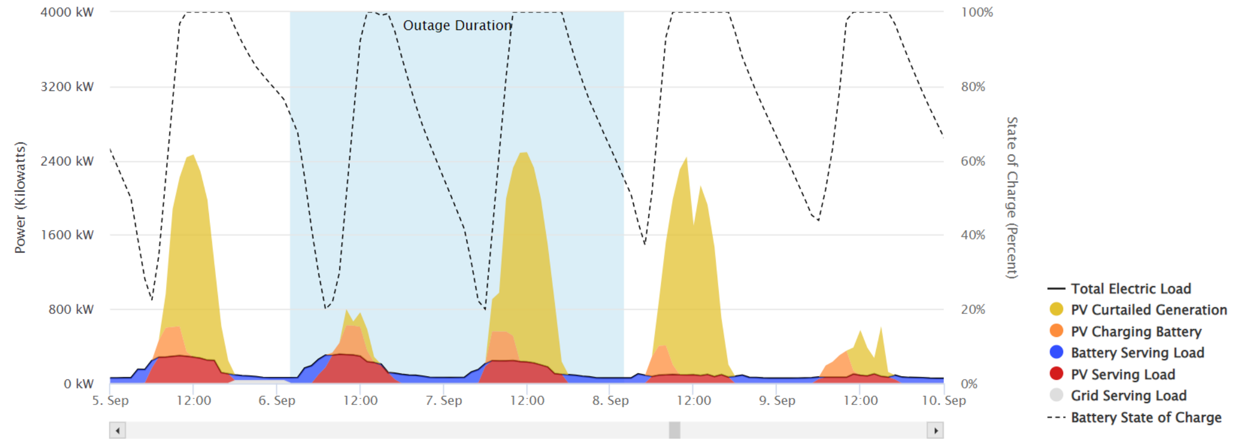


Figure 19. 48-hour Outage System Performance, Amherst Regional Middle School, with ground mount

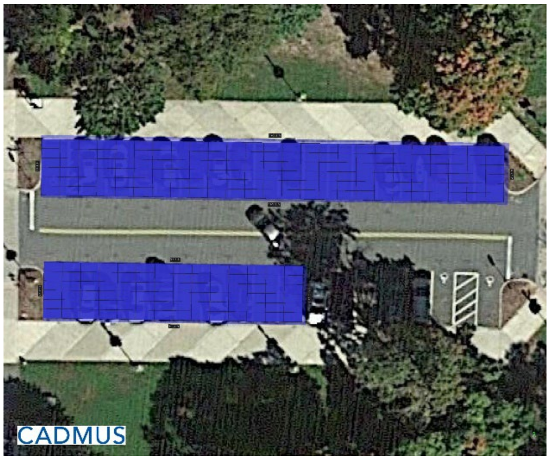


Parking Lots

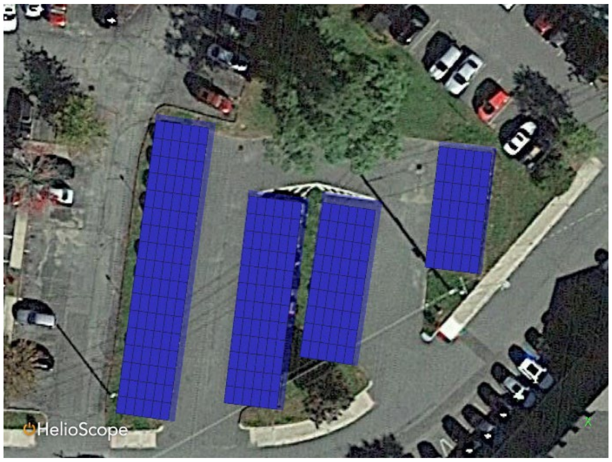
The Parking Lots have the capacity to support a solar PV installation estimated at a combined total of 367 kW-DC. An array of this capacity would generate approximately 440,658 kWh annually. This usage can be virtually net metered to other Town electricity accounts. For the purposes of this analysis, Spring Street and Pray Street lots were modeled to offset 200,000 kWh annually, and the Boltwood Garage was modeled to offset 400,000 kWh annually. All sites were modeled with the G-0 Eversource West rate. The lifetime NPV savings will vary depending on how much electric usage is virtually net metered.

Table 14. Parking Lot Sites Summary

Metric	Spring Street Lot	Pray Street Lot	Boltwood Garage
DC Capacity (kW)	86.6	99.9	180.2
AC Capacity (kW)	67.9	78.3	141.2
No. Modules	234	270	487
Est. Year 1 PV Generation (kWh)	110,093	117,233	213,332
Installation Cost ($/kW-DC)	$3125	$3124	$3123
Total Installation Cost ($)	$270,653.60	$312,108.65	$562,831.94
Lifetime NPV Savings ($)	$28,214	$5,287	$31,241



Spring Street Lot

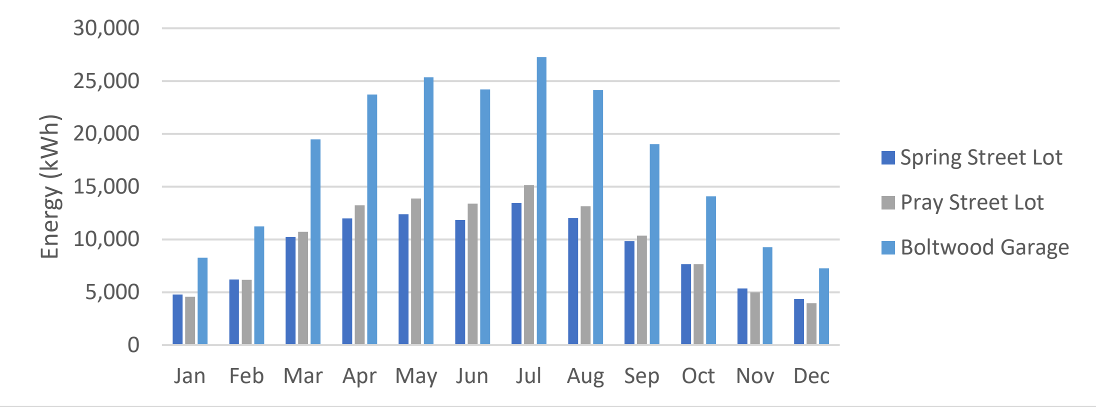


Pray Street Lot

Boltwood Garage

As shown in Figure 20 below, the total estimated annual generation of the parking lot carports is about 440,000 kWh, which can be virtually net metered to other Town sites without onsite generation.

Figure 20. Estimated Annual Solar Production Parking Lot Sites



Cherry Hill Golf Course

The Cherry Hill Golf Course has the capacity to support a solar PV installation estimated at 13.3 kW-DC. An array of this capacity would generate approximately 15,926 kWh annually, enough to offset 53% of the site's annual electricity usage.

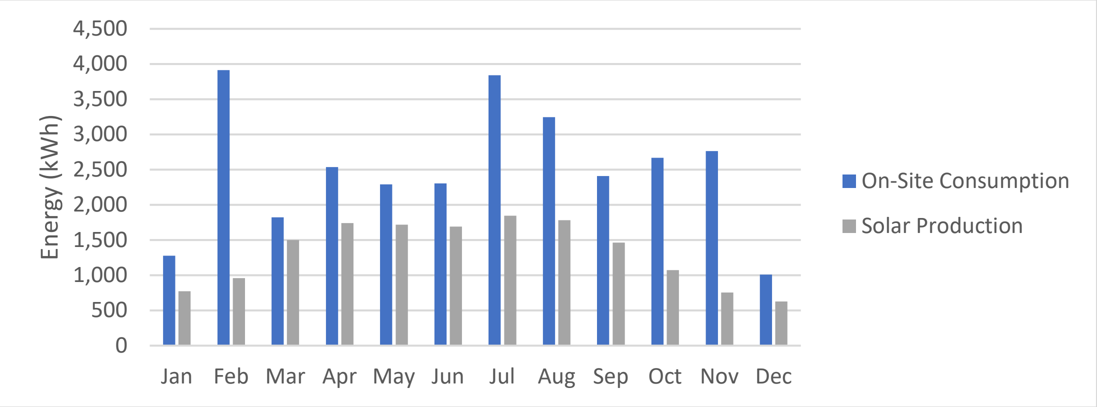
Table 15. Cherry Hill Golf Course Site Summary

Cherry Hill Golf Course System Details	
DC Capacity (kW)	13.3
AC Capacity (kW)	10.4
No. Modules	36
Est. Year 1 PV Generation (kWh)	15,926
On-Site Load Offset by PV Generation	53%
Installation Cost ($/kW-DC)	$3,310
Total Installation Cost ($)	$44,023
Lifetime NPV Savings ($)	$505

Cherry Hill Golf Course Carport

As shown in Figure 21 below, onsite consumption is estimated to exceed solar generation every month, though even a relatively small carport array is estimated to offset more than half of onsite consumption.

Figure 21. Estimated Annual Solar Production vs On-Site Consumption at Cherry Hill Golf Course



Appendix B. SMART Program Information

The program has a variety of "adders" which can increase or decrease the incentive payment by project based on its desirability to the state (e.g., large ground-mounted projects are discouraged, and brownfield sites are encouraged). Adder amounts vary and are categorized by location type (e.g., roof, ground), off-taker type (e.g., governmental, low-moderate-income) and energy storage. The program has a declining block framework, so as more projects come online, and a capacity block fills, the incentive levels decline in an effort to mirror forecasted cost declines for the technology. Projects larger than 25 kW-AC receive a 20-year fixed incentive rate determined at the time of application approval, while smaller projects receive a 10-year fixed incentive. The incentive program has been adjusted multiple times throughout its existence and is likely to be modified in the future as the boom in solar installations continues.[18]

It is important to note that any solar PV project in Massachusetts that takes advantage of the financial benefits of the SMART program, regardless of ownership option pursued, relinquishes the environmental attributes or renewable energy certificates (RECs) ascribed to the energy their system produces. Instead, the RECs generated by the solar PV installation are transferred to the utility, and count towards their compliance with the state mandated Renewable Portfolio Standard (RPS). This means that in order for the Town to claim they are powered by on-site carbon-free renewable energy, they would need to sacrifice the financial benefits offered via the SMART program, which often decreases the financial viability of solar PV projects in MA considerably. However, if the Town does wish to offset a percentage of their energy usage via renewable energy and participate in the SMART program, they could purchase RECs of their own. These REC purchases, which can be sourced from local renewable energy projects or from renewable energy generation elsewhere in the U.S., are often a more cost-effective way of offsetting electricity use in MA than sacrificing the value of SMART.

Table 17 provides an overview of how the SMART incentive payments are calculated for a representative site, the Amherst-Pelham Regional High School. In addition to the savings from avoided costs and any on-bill credits, the Town will be compensated at this SMART incentive payment rate for each kWh of energy their systems produce based on system specifications detailed below. Note that these are the current estimated values for the system, which are subject to change as more systems are enrolled in the SMART program. Because most sites were modeled with a roof array and a carport array, a combined SMART incentive was calculated, weighted based on the capacity (kW) proportion of each array to the total. This aggregated SMART incentive rate was used as an input in the energy storage and financial models. If the Town opts to retain the RECs for the renewable energy their solar PV systems generate, then they would also forego the SMART incentive payment for that energy.

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[18] Note: Until the DPU officially approves the new SMART Tariff, the DOER is unable to issue preliminary Statements of Qualification for projects seeking allocation to expanded program capacity. Accordingly, as described in Section 7 of the Statement of Qualification Reservation Period Guideline, projects applying for additional Capacity Blocks in National Grid will be placed on a waitlist called "400 MW Hold." More information will be provided to stakeholders as it becomes available. At the time of this memo, the SMART Tariff had not been officially approved.

Table 16. Base SMART Compensation Rates, Eversource West, SMART block 11

Generation Unit Capacity	Base Compensation Rate ($/kWh)
Low income less than or equal to 25 kW AC	$0.23242
Less than or equal to 25 kW AC	$0.20211
Greater than 25 kW AC to 250 kW AC	$0.15158
Greater than 250 kW AC to 500 kW AC	$0.12632
Greater than 500 kW AC to 1,000 kW AC	$0.11116
Greater than 1,000 kW AC to 5,000 kW AC	$0.10105

Table 17. Buildup of SMART Incentives, Amherst-Pelham Regional High School

Select Results	Unit	Calculation	Roof Array	Carport Array	Combined
Eversource SMART Solar Block	Block #		11	11	11
Base SMART Compensation Rate*	$/kWh	A	$0.11116	$0.12632	-
Adders					
Location-Based Adders					
Category	Text		Building	Canopy	-
Value	$/kWh	B1	$0.01920	$0.06000	-
Offtaker-Based Adders					
Category	Text		Public Entity	Public Entity	-
Tranche	Tranche #		2	2	-
Value	$/kWh	B2	$0.03840	$0.03840	-
Energy Storage Adders					
Tranche	Tranche #		11	11	-
Value	$/kWh	B3	$0.02627	$0.02627	-
Total SMART Compensation Rate	$/kWh	C1=A+B1+B2+B3	$0.19503	$0.25099	-
Eversource Tariff					
Tariff Class	Text		G-2	G-2	-
Estimated Value of Energy**	$/kWh	D	$0.10894	$0.10894	-
Estimated SMART Incentive Rate	$/kWh	E1=C1-D	$0.08609	$0.14205	$0.10615
Term of SMART Incentive	Years		20	20	20

*Note that the base SMART compensation rate for small solar PV systems (≤25 kW-AC) are higher than that of larger systems.

**Aggregate of kWh-based charges: three-year basic service rate average, transmission, distribution, and transition charges.

Table 18. SMART Adders and Incentives by Scenario

Site Name	Rate Class	Array	SMART ESS Adder ($/kWh)	SMART Solar Incentive Payment ($/kWh)	Weighted Solar Incentive Payment ($/kWh)
Bangs Community Center	G-2	Building	$0.04014	$0.1872	$0.18115
		Carport	$0.03749	$0.1340	
	G-2	Building, tree removal	$0.04014	$0.1775	$0.16005
		Carport, tree removal	$0.03749	$0.1748	
Amherst Police Department	G-2	Building	$0.04037	$0.1874	$0.21359
		Carport	$0.04037	$0.2282	
North Fire Station	G-0	Building	$0.02990	$0.1189	$0.14109
		Carport	$0.02990	$0.1597	
Crocker Farm Elementary	G-2	Building	$0.02503	$0.1215	$0.13341
		Carport	$0.02503	$0.1623	
		Carport, tree removal	$0.02098	$0.1583	$0.13528
Regional High School	T-2	Building	$0.02627	$0.0861	$0.10615
		Carport	$0.02627	$0.1420	
Regional Middle School	G-2	Building	$0.02659	$0.0827	$0.10327
		Carport	$0.02659	$0.1386	
		Ground Mount	$0.02659	$0.1039	$0.10338
Spring Street Lot	G-0	Carport	-	$0.12982	$0.12982
Pray Street Lot	G-0	Carport	-	$0.12982	$0.12982
Boltwood Garage	G-0	Carport	-	$0.12982	$0.12982
Cherry Hill Golf Course	G-0	Carport	-	$0.18035	$0.18035

Appendix C. Clean Peak Standard Program Information

Table 19. Clean Peak Standard Applicable Multipliers

Multiplier Category	Multiplier	Applies?	Applicable Multiplier
Seasonal	Varies	Yes	1 or 4
Resilience	1.5	Yes	1.5
Existing Resource	0.01	No	1
SMART ES	0.3	Yes	0.3
		Final Multiplier	**0.45**

Table 20. Clean Peak Standard Season Timing and Multipliers

Season	Period Start	Period End	Peak Start	Peak End	Seasonal Multiplier
Spring	1-Mar	14-May	5:00 PM	9:00 PM	1
Summer	15-May	14-Sep	3:00 PM	6:59 PM	4
Fall	15-Sep	30-Nov	4:00 PM	8:00 PM	1
Winter	1-Dec	28-Feb	4:00 PM	8:00 PM	4

Table 21. Clean Peak Standard Estimated CPEC Prices, 2023 to 2035

Year	Discount to ACP	CPEC Estimated Price ($/MWh)
2023	25%	$33.75
2024	50%	$22.50
2025	50%	$21.73
2026	50%	$20.96
2027	50%	$20.19
2028	50%	$19.42
2029	50%	$18.65
2030	50%	$17.88
2031	50%	$17.11
2032	50%	$16.34
2033	50%	$15.57
2034	50%	$14.80
2035	50%	$14.03

Appendix D. ConnectedSolutions Program Information

To be eligible for the program, the battery storage system must be located behind-the-meter (BTM) asset, the inverter must be from Generac, SolarEdge, Enphase, or Tesla, and the participant must pay into the energy efficiency charge, which is the case for all Amherst sites. The incentive level is locked in for the first 5 consecutive years. After the fifth year of participation, the customer will receive the incentive rate (if any) offered by the program administrator at that point in time. Due to the high value add of demand response, it's expected that the program will continue for at least another 5 additional years, so Cadmus modeled the incentive for 10 years, with a net present value discount rate of 5.64%.

For commercial and industrial (C&I) customers, there are two separate programs within the ConnectedSolutions umbrella: daily dispatch or targeted dispatch, shown in Table 22 below. Participants in each program receive day-ahead notice of "events," (no longer than three hours) in which customers must reduce load or utilize energy storage and load reduction. Day-ahead notice is provided to the curtailment service provider and/or directly to the customer by email or text. There is no penalty for not participating in a single event other than the reduction in incentives based on average kilowatts dispatched. ConnectedSolutions takes into account events that may require energy storage to be used for resiliency purpose (e.g., major storm events), and do not call events if a resiliency need is expected.

Table 22. ConnectedSolutions Program Information for Eversource Territory

Program Info	Daily Dispatch	Targeted Dispatch
Incentive	$200 / avg kW reduction	$100 / avg kW reduction
Season Dates	June 1 – September 30	June 1 – September 30
Maximum Number of Events	60	8
Event Timing	Between 2:00pm – 7:00pm Non-holiday weekdays	Between 2:00pm – 7:00pm Non-holiday weekdays
Event Duration	2-3 hours	3 hours
Notification	Day before the event by phone, email, and/or text	Day before the event by phone, email, and/or text

In addition, the battery inverter is required to stream near real time data to the DERMS platform, so the vendor would need to be integrated to stream data, receive notifications, and backfill missing data.

Table 23 illustrates the expected revenue from participation in ConnectedSolutions for each site under various scenarios. The average kW reduced per event is based on the average load between June 1 to September 30 between 2pm and 7pm on non-holiday weekdays only. For the Middle and High School, these values are from actual 15-minute interval data and represent about 45% of the annual peak demand/ESS power of the site. All other sites without interval data available have an estimated average kW reduced per event using 45% times the site's annual peak demand. The number of events participated in is 58 for all daily dispatch, 2 events less than the maximum of 60 to offer a more conservative estimate. All targeted dispatch scenarios participate in the eight events, the maximum.

Table 23. ConnectedSolutions Scenarios and Revenue

Site	Period	Average kW Reduced/Event	# of Events Participated	Annual Revenue
Amherst-Pelham Regional High School	Daily Dispatch	140	58	$27,067
Amherst-Pelham Regional High School	Targeted Dispatch	140	8	$14,000
Amherst Regional Middle School	Daily Dispatch	136	58	$26,293
Amherst Regional Middle School	Targeted Dispatch	136	8	$13,600
Crocker Farm Elementary School	Daily Dispatch	45	58	$8,700
Crocker Farm Elementary School	Targeted Dispatch	45	8	$4,500
Bangs Community (Senior Center), 70 kW ESS	Daily Dispatch	31.5	58	$6,090
Bangs Community (Senior Center), 70 kW ESS	Targeted Dispatch	31.5	8	$3,150
Bangs Community (Senior Center), 64 kW ESS	Daily Dispatch	28.8	58	$5,568
Bangs Community (Senior Center), 64 kW ESS	Targeted Dispatch	28.8	8	$2,880
Amherst Police Department, 100 CLF	Daily Dispatch	59.4	58	$11,484
Amherst Police Department, 100 CLF	Targeted Dispatch	59.4	8	$5,940
Amherst Police Department, 50 CLF	Daily Dispatch	28.8	58	$5,568
Amherst Police Department, 50 CLF	Targeted Dispatch	28.8	8	$2,880
North Fire Station	Daily Dispatch	15.75	58	$3,045
North Fire Station	Targeted Dispatch	15.75	8	$1,575

As shown above, daily dispatch offers greater financial return than targeted dispatch, so this is the scenario Cadmus used in estimating total lifetime demand response revenue. In practice, the choice of daily vs. targeted dispatch should be evaluated on a per site basis. Sites that can't participant in many events may be better suited to targeted dispatch. The Eversource ConnectedSolutions team can be contacted to provide more detailed information and recommendations.