ConnectedSolutions

THE NEW ECONOMICS OF SOLAR+STORAGE FOR AFFORDABLE HOUSING IN MASSACHUSETTS

CleanEnergyGroup

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ABOUT THIS REPORT

ConnectedSolutions: The New Economics of Solar+Storage for Affordable Housing in Massachusetts presents the results of an analysis to evaluate the impact of the Massachusetts ConnectedSolutions customer-sited battery program on the economics of pairing solar PV with battery storage (solar+storage) at multifamily affordable housing properties. The economics of solar and storage were assessed for six Massachusetts affordable housing properties under two scenarios—one with ConnectedSolutions and one without the program. The analysis found that, compared with other business cases, participation in ConnectedSolutions significantly improves the economic viability of solar+storage for these multifamily housing properties.

The report was produced for the Resilient Power Project (*www.resilientpower.org*), a joint project of Clean Energy Group and Meridian Institute. The Resilient Power Project works to accelerate market development of resilient, clean energy solutions in low-income and underserved communities to further clean energy equity by ensuring that all communities have access to the economic, health, and resiliency benefits that solar+storage can provide. The Resilient Power Project is supported by The JPB Foundation, The Kresge Foundation, Surdna Foundation, Nathan Cummings Foundation, The New York Community Trust, Barr Foundation, The John Merck Fund, and Merck Family Fund.

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DISCLAIMER

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142-kilowatt solar system developed and installed by Sunbug Solar across nine buildings at The Residences at Melpet Farm in Dennis, MA, a Preservation of Affordable Housing (POAH) and Housing Assistance Corporation property. Source: Sunbug Solar

Executive Summary

Despite the economic benefits that solar PV paired with battery storage (solar+storage) and the importance of reliable resilient power for multifamily affordable housing properties—and at housing properties serving elderly populations and individuals with electricity-dependent medical needs—few affordable housing properties have installed solar+storage systems. Those that have succeeded in installing solar+storage have often depended on significant grant support to make the projects financially viable.

This report explores a new battery storage program that is beginning to change this narrative. When the ConnectedSolutions program was initially launched in Massachusetts in 2019, it became the first program in the country to use state energy efficiency funds to support the development of customer-sited battery storage as a demand reduction measure. The design of the program makes it accessible to nonprofit entities—like many affordable housing providers—and creates an opportunity for any type of facility to generate an economic return through battery storage investments, regardless of how the property uses energy or how it is billed for electricity. Because ConnectedSolutions pays for performance based on a multi-year contract between the customer and their electric utility, the program makes battery storage revenues more predictable and reduces project investment risk.

To evaluate the impact of the ConnectedSolutions program on affordable housing properties, the economics of solar+storage was assessed for six multifamily affordable housing properties in Massachusetts. The financial feasibility of solar+storage for each property was explored under two scenarios: one with participation in the ConnectedSolutions program and one where ConnectedSolutions was not available. Nonprofit and for-profit ownership scenarios were also explored. While the results detailed in this report are specific to multifamily affordable housing properties, they are widely applicable to all types of facilities where the ConnectedSolutions program is available.

These analyses produced several important findings, including the following:

- Without ConnectedSolutions, most of the properties would not have been able to economically install a solar+storage system.
- With ConnectedSolutions, solar+storage project internal rates of return (IRR) improved by an average of more than 30 percent, net present values (NPV) increased an average of more than $80,000, and simple payback periods (SPP) for projects decreased by one to three years.
- ConnectedSolutions resulted in larger, longer duration battery systems able to deliver greater utility bill savings to housing providers and greater energy resilience to protect vulnerable residents during power outages.
- ConnectedSolutions improves the financeability of solar+storage projects by reducing uncertainty with the provision of five-year contracts between the utility and participating battery system owners, resulting in consistent revenue opportunities based on utility signals. This represents a significant reduction of economic risk compared to dependence on savings through reducing utility demand charges, which relies on the battery owner to successfully manage variable, difficult-to-predict onsite peaks in energy demand.
- Because ConnectedSolutions results in customer battery systems being dispatched at more beneficial times for the grid, the program helps to democratize the benefits of battery storage by delivering savings to all ratepayers.

Based on the findings, it is strongly recommended that policymakers interested in expanding solar+storage access in difficult-to-reach sectors, such as affordable housing and community-serving facilities, should pursue the design and implementation of a customer-sited battery program with elements similar to the ConnectedSolutions model.

84-kilowatt solar system developed by Resonant Energy and installed by ACE Solar at Dewitt Community Center in Boston, MA, a Madison Park Development Corporation property.
Source: Resonant Energy

Introduction

Over the past several years, Clean Energy Group (CEG), a national nonprofit organization, has assisted affordable housing providers in exploring the technical and financial feasibility of developing solar PV paired with battery storage (solar+storage) at properties across their portfolios.[1] Much of this work has been focused on the Northeast, where CEG first launched its Resilient Power Project in the wake of Superstorm Sandy, with the goal of helping low-income and climate-vulnerable communities strengthen the energy resilience of essential facilities, such as community centers, health clinics, and multifamily affordable housing properties. Affordable housing has always been a key focus for the work as many facilities serve aging populations, individuals with electricity-dependent medical needs, and residents with limited resources to relocate during climate emergencies.

When this effort first began, solar+storage installations were often developed as demonstration projects, which were only economically viable due to significant grant support provided by states, foundations, and federal agencies. However, the economics of solar+storage have changed over time as technology costs have fallen and new market opportunities have emerged. This report explores one of the most promising of these market opportunities, a utility battery storage program in Massachusetts called ConnectedSolutions, and how the program has transformed the economics of solar+storage for affordable housing properties.[2]

With ConnectedSolutions, which was developed based on analysis supported by CEG[3], the Commonwealth of Massachusetts became the first state to incorporate customer-sited, behind-the-meter battery storage into its energy efficiency plan, as a tool to reduce peak energy demand on the grid.[4] Essentially, ConnectedSolutions rewards participating utility customers for discharging stored energy during times of high demand for electricity across all customers within the utility's service territory. This helps the utility avoid using other, higher-cost ways of meeting peak demand needs, such as calling on expensive, inefficient peaker power plants to operate.[5] To learn more about how ConnectedSolutions works, see the box below.

This report explores one of the most promising of these market opportunities, a utility battery storage program in Massachusetts called ConnectedSolutions, and how the program has transformed the economics of solar+storage for affordable housing properties.

This report represents the first independent, public analysis of the impact of ConnectedSolutions on the economics of solar+storage systems at multifamily affordable housing properties. As detailed in the following sections, the structure of Connected Solutions significantly improves the economic viability of solar+storage for multifamily properties across the state, whereas, without ConnectedSolutions, the development of solar+storage would not be economical for the majority of properties analyzed. While this analysis was limited to multifamily affordable housing properties in Massachusetts, the results and key findings are broadly applicable to all types of facilities where the ConnectedSolutions program is available.

MASSACHUSETTS CONNECTEDSOLUTIONS PROGRAM

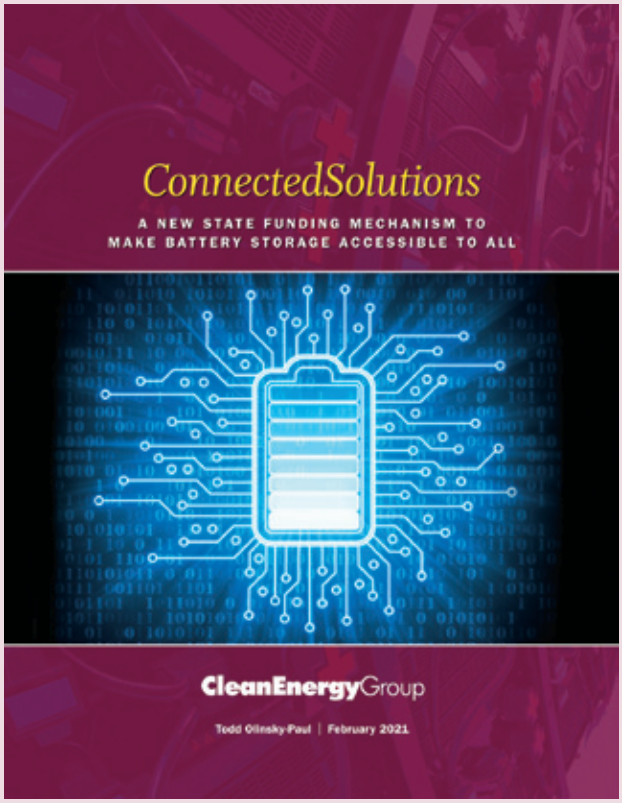
How It Works

The ConnectedSolutions customer battery storage program was launched in 2019 with the goal of reducing utility peak demand expenses in Massachusetts. The program provides payments to customer-sited battery systems that discharge stored energy during specific times throughout the year. ConnectedSolutions is based on a pay-for-performance model, meaning that utility customers, or third-party energy storage providers, own the battery systems, and utilities pay only for the demand reduction services delivered.

ConnectedSolutions is part of the Massachusetts three-year energy efficiency plan. Instead of reducing energy consumption (kilowatt-hours) like most energy efficiency measures, batteries reduce the maximum level of demand for energy (kilowatts). Instead of calling on expensive, seldom used fossil-fuel power plants, known as peakers, during times of high energy demand, utilities can call on customer-sited batteries to discharge stored energy when needed.

The three largest Massachusetts utilities, Eversource, National Grid, and Until, all participate in the Connected-Solutions program, though each implements the program with slight variations. To participate in the program, customers with battery systems enter into a five-year contract with their utility. The contract does not sign over control of the battery system or commit the customer to discharge the battery at any given time, it merely guarantees that the customer can participate in Connected-Solutions for at least the five-year term of the contract.

Participating utility customers can choose to include their batteries in one or two of three different programs: a winter seasonal program, a summer daily dispatch program, and a summer targeted dispatch program. Customers can participate in one summer program, but not both, along with the winter program. Each of the three programs has its own rate for customer performance payments. Customers receive compensation when their battery system successfully discharges energy during a peak demand event. Most events are three hours in duration, and battery owners are typically notified 24 hours before an event occurs. Batteries participating in the program will typically be managed either by software that can respond to the utility signals or through an agreement with a third party that manages the battery



performance. There is no penalty for failing to respond to an event, but this will reduce the customer's average response rate (and lower the performance payment) for the season.

As an example: If a commercial customer with a 60-kilowatt-hour battery system were to sign up for the summer daily dispatch program, which offers a compensation rate of $200 per kilowatt, and responded perfectly to each three-hour event, their maximum payment for the season would be $4,000 (60 kilowatt-hours/3 hours X $200 per kilowatt). Over the five-year term of a contract, the customer could earn up to $20,000 just for participating in the summer portion of the program.

For more information about the policy implications of ConnectedSolutions and how such a program could be implemented in other states, see *Connected Solutions: A New State Funding Mechanism to make Battery Storage Accessible to All* at https://www.cleanegroup.org/ceg-resources/resource/connected-solutions-policy.

A 48-kilowatt solar system developed by Resonant Energy and installed by ACE Solar at Hibernian Hall in Boston, MA, a Madison Park Development Corporation property.
Credit: Resonant Energy

Analysis Methodology

To evaluate the potential impact of the ConnectedSolutions program on the economics of solar+storage for affordable housing, Clean Energy Group, American Microgrid Solutions, and muGrid Analytics conducted techno-economic analyses, using property details and electricity consumption data from six multifamily affordable housing properties in Massachusetts, shown in Table 1 as Sites 1–6.[6]

The techno-economic feasibility analysis for each site evaluated solar PV and battery storage solutions in terms of both their operational and financial performance over the life of the project. From the technical side, the analysis considered solutions that could be engineered, installed, and operated under the requirements and constraints of both the site and the electric utility. To find the most economical energy solution, the analysis selected system sizes that would produce the greatest value to the owner over time.

The analyses were performed using muGrid Analytics' Redcloud tool—a design and dispatch optimization platform that models the performance of a combination of distributed generation and energy storage assets within the specific conditions of the site and its utility. Redcloud identifies the optimal mix of assets, sizes, and operating characteristics to meet the host site's goals, and accounts for capital costs (equipment, installation, replacement), operating costs (fuel, maintenance, service), utility bill savings, and revenue from programs and incentives. Redcloud determines optimal sizing and dispatching of energy assets that maximizes the value of solar+storage over time for the system owner.

The economic impact of ConnectedSolutions was determined by modeling two scenarios: one scenario where the ConnectedSolutions program does exist and one where the program does not. For the scenario without ConnectedSolutions, the main economic driver for battery storage is to reduce utility demand charges. These are charges based on the highest level of demand for electricity during a billing period, measured in kilowatts.[7] Some utilities, like Eversource, tend to have relatively high demand charges for certain commercial customers. Other utilities, such as National Grid, have lower demand charges, making it challenging to offset the cost of battery storage through demand charge bill savings alone. Both scenarios

The economic impact of ConnectedSolutions was determined by modeling two scenarios: one scenario where the ConnectedSolutions program does exist and one where the program does not.

TABLE 1
Multifamily Affordable Housing Property Details

Property	Units	Age	Utility	Rate Tariff
Site 1	209	1978 (Renovated 2018)	Eversource	B7
Site 2	146	1984 (Renovated 1998)	Eversource	B7
Site 3	98	Under construction	Eversource	Cambridge G2
Site 4	150	2010	Eversource	Boston G2
Site 5	154	2002	National Grid	G2
Site 6	134	2012	National Grid	G2

include economic benefits from avoided energy costs due to solar generation offsetting grid usage and net metering credits, as well as incentives available through the Solar Massachusetts Renewable Target (SMART) program (see Box).

Two ownership scenarios were also evaluated: one where the solar+storage system is owned by a nonprofit, *tax exempt* entity and a second scenario where the system is owned by a for-profit, *taxable* entity. In both scenarios, it is assumed that the solar+storage system owner is the same entity that pays the electricity bills for the property. Many affordable housing providers are nonprofit organizations, which cannot directly take advantage of tax credit incentives for solar and energy storage. There are ways that a nonprofit can realize some of the benefits from incentives like the federal investment tax credit (ITC) for solar, such as working with a third-party provider or tax-equity investor.[8] These options were not fully explored in this analysis, though the results for taxable entities show the total benefits a nonprofit housing provider and a for-profit third party could realize through a partnership arrangement. Under this type of arrangement, a third party that qualifies for the tax incentives would pay for the construction, installation, operation, and maintenance of the solar+storage system. The nonprofit entity would either purchase electricity from the system at a negotiated rate through a power purchase agreement (PPA) or lease the system.

To compare the results evenly between the sites, many site conditions and development considerations—such as roof conditions, installation costs, and interconnection constraints—were normalized across all properties. Solar sizing was held constant for each individual site through all scenarios. This was done to assess the impact of ConnectedSolutions on the economics of battery storage without the complexity of varying solar system sizing as well. Solar sizing for each site was determined either by referencing existing solar design specifications for the property or maximizing available space for solar siting, up to a production cap of 100 percent of annual electricity consumption. While the analyses do not evaluate the sites for specific solar or battery storage products, system sizing, costs, and configurations are based on products widely available in the market today. This means that the model adjusts the optimized results to fit the closest inverter and battery storage system sizing that is commercially available.

Developers, investors, and property owners use a range of financial metrics to evaluate the economic feasibility of a project. The results for each site and ownership scenario in this analysis were compared using three common metrics: internal rate of return (IRR), net present value (NPV), and simple payback period (SPP). IRR is a measure of how profitable an investment will be. The higher the IRR, the more attractive the investment opportunity. NPV is the sum of future cash flows, anticipated revenue, and savings versus expenses, in today's dollars. In general, a positive NPV suggests that a project is worth pursuing. SPP is the time it takes for a project's benefits (revenue, savings, incentives) to offset its costs.

Solar Massachusetts Renewable Target (SMART)

142-kilowatt solar system developed and installed by Sunbug Solar across nine buildings at The Residences at Melpet Farm in Dennis, MA, a Preservation of Affordable Housing (POAH) and Housing Assistance Corporation property. Source: Sunbug Solar

The Solar Massachusetts Renewable Target (SMART) program was established as a long-term incentive to catalyze the development of 1,600 megawatts of new solar capacity in Massachusetts. The program offers 10-year or 20-year fixed-price incentives that set compensation rates for solar generation based on project size, along with incentive adders for specific project attributes.

On November 26, 2018, the SMART incentives became available to solar projects of all types and sizes, up to five megawatts. SMART is designed as a declining block program, which means that the program's per kilowatt-hour incentive levels decline over time as more solar capacity is installed in the state. Each block of solar capacity includes carveouts for small projects (25 kilowatts or less) to encourage projects of all sizes to participate. The program also features stackable adders that increase the incentive rate for projects that include certain features, such as energy storage systems and community solar. SMART solar installations of 500 kilowatts or larger are now required to include battery storage.

To receive compensation, solar system owners register with the program and receive payments directly from their distribution utility for each kilowatt-hour of solar energy produced. For more information about the Solar Massachusetts Renewable Target (SMART) program, see https://www.mass.gov/solar-massachusetts-renewable-target-smart.

A 32-kilowatt solar system developed by Resonant Energy and installed by ACE Solar at Dudley Greenville in Boston, MA, a Madison Park Development Corporation property. Source: Resonant Energy

Analysis Results

As shown in the following table and figures, the availability of the ConnectedSolutions program significantly improved the economic feasibility of solar+storage for all multifamily affordable housing properties analyzed in this study. In fact, without ConnectedSolutions, even a small battery storage system was not found to be an economically optimal solution for four of the six sites analyzed. Overall, ConnectedSolutions boosted IRRs by an average of about 30 percent, increased NPVs by tens of thousands of dollars, and reduced project payback periods by one to three years.

Participating in ConnectedSolutions differs from engaging in demand charge management in several ways that affect the optimum battery size for the systems studied. One major difference is that ConnectedSolutions is designed to reduce systemwide demand for electricity, as opposed to site-specific demand. This means that battery systems participating in ConnectedSolutions are rewarded for their performance during three-hour dispatch windows, achieving greater economic returns by delivering more power for a longer duration than systems optimized for managing onsite demand to reduce utility demand charges, which typically targets much shorter peak periods. Also, under ConnectedSolutions, battery owners are credited not just for onsite load reduction, but also for

Overall, ConnectedSolutions boosted IRRs by an average of about 30 percent, increased NPVs by tens of thousands of dollars, and reduced project payback periods by one to three years.

any power discharged to the grid during regional peaks, meaning that batteries participating in ConnectedSolutions are not limited in their revenue potential by the size of the load of the host facility. For these reasons, ConnectedSolutions favors the development of bigger battery systems, with higher power and energy ratings than those designed for demand charge management alone, as shown in Table 2.

It is worth noting that ConnectedSolutions offers a distinct economic advantage over demand charge management for many types of facilities that have relatively flat load profiles (few spikes in demand) and therefore are not able to reduce costs much by lowering their own peak demand. The multifamily properties studied in this report provide a good example of this phenomenon. Because these types of facilities tend to

TABLE 2
Solar+Storage System Sizing Results for Six Multifamily Affordable Housing Properties

Property	Solar (kW)	Battery (No ConnectedSoultions)		Battery (With ConnectedSoultions)	
		Power (kW)	Energy (kWh)	Power (kW)	Energy (kWh)
Site 1	116	40	80	70	140
Site 2	250	80	160	130	260
Site 3	105	—	—	50	100
Site 4	222	—	—	60	180
Site 5	120	—	—	70	140
Site 6	40	—	—	30	60

have rather flat loads, with broad peaks sometimes lasting hours, significant onsite peak load reduction to lower utility demand charge expenses would be difficult to achieve. For these sites, and many other facilities with similarly shaped load profiles, reducing demand charges simply would not offset the cost of a battery. This is doubly true for the sites located in National Grid's service territory (Sites 5 and 6), which are subject to fairly low demand charge rates. With ConnectedSolutions, utility demand charge rates and facility load profiles are no longer essential for battery storage to make economic sense. In fact, utility rates and onsite energy consumption pattern have no bearing on the economic potential for ConnectedSolutions participation.

For facilities that do have demand charges that can be managed and reduced with battery storage, the larger battery systems supported by ConnectedSolutions participation are more likely to be able to reliably reduce a site's peak demand and related demand charges. Although demand charge reduction was not prioritized in modeling systems optimized for participation in ConnectedSolutions, the sites did realize additional demand charge savings. With larger battery systems, the sites achieved about 20 percent greater electric utility bill savings versus smaller batteries optimized for demand charge management without the ConnectedSolutions program.

INTERNAL RATE OF RETURN (IRR)

IRRs for solar+storage systems optimized with the ConnectedSolutions program were found to average 26 percent greater for nonprofit, tax exempt entities and 36 percent greater for taxable entities, as compared to scenarios without ConnectedSolutions. With ConnectedSolutions, IRRs ranged from 7.8 percent to 12.1 percent for nonprofit entities (Figure 1A, p.12) and from 10.7 percent to 15.2 percent for for-profit entities (Figure 1B, p. 12). For reference, an IRR of around 8 percent is sometimes viewed as the minimum threshold for an attractive investment. Nearly all the projects evaluated would exceed that threshold with ConnectedSolutions.

NET PRESENT VALUE (NPV)

As with IRR, all scenarios with ConnectedSolutions outperformed demand charge management optimized systems without ConnectedSolutions when comparing NPVs. For nonprofit entities, NPVs increased by $19,000 to $189,000 with ConnectedSolutions, depending on the size of the project (see Figure 2A, p.13). Taxable entities realized NPV gains ranging from $23,000 to $149,000 with ConnectedSolutions (Figure 2B, p.13).

In several cases, the introduction of ConnectedSolutions turned projects that appeared to be poor or marginal investments with negative NPVs into promising investment opportunities with positive NPVs. This was the case for Site 3 under a nonprofit ownership scenario and Sites 4, 5, and 6 under a for-profit ownership structure.

For all sites, NPVs and IRRs were higher in ownership structures with a taxable entity that could take advantage of the ITC. As shown in Figure 2A (p.13), nonprofit owned solar+storage systems for three of the sites still resulted in negative NPVs even with ConnectedSolutions. This is a reflection of the poor economics of solar at these properties; it was not an indication that battery storage or ConnectedSolutions are ineffective for these sites. In all cases, adding batteries participating in ConnectedSolutions to solar resulted in improved NPV outcomes. It is also important to note that NPV results are highly dependent on the discount rate used in the analysis, which is specific to individual entities based on their target rate of return on investments. For these analyses, a discount rate of 9 percent was used. Using a lower discount rate would improve NPV results.

IRRs for solar+storage systems optimized with the ConnectedSolutions program were found to average 26 percent greater for nonprofit, tax exempt entities.

SIMPLE PAYBACK PERIOD (SPP)

SPP is one of the most straightforward metrics to assess the economic differences between two scenarios. The value represents the number of years it would take for the economic benefits of a project to pay for the initial investment. As the name implies, it's a simplified approach; however, it is useful for quick comparisons that do not depend on project life and discount rate assumptions as do IRR and NPV.

Again, the existence of ConnectedSolutions improved values across all scenarios. For both ownership arrangements, systems optimized with ConnectedSolutions had SPPs that averaged 17 percent shorter than without the program, ranging from one to three years shorter. In the case of nonprofit entities (Figure 3A, p.14), SPPs decreased by an average of nearly two years, dropping from an average SPP of 10.8 years to 8.9 with Connected-Solutions. Taxable ownership scenarios (Figure 3B, p.14) dropped from an average SPP of 8.0 years without ConnectedSolutions to 6.6 years with the program.

These results are even more significant when considering the increased upfront investment for projects participating in ConnectedSolutions, which included much larger, more expensive battery systems. This means that the financial returns with ConnectedSolutions were high enough to pay off the greater investment in battery storage over a shorter period of time. In fact, projects that would not include batteries without participation in ConnectedSolutions (Sites 3–6) saw the biggest reductions in SPP years when program participation was included, up to a 2.9 year decrease in SPP for the Site 6 nonprofit ownership scenario.

FIGURE 1A

Internal Rate of Return (Tax Exempt Entity)

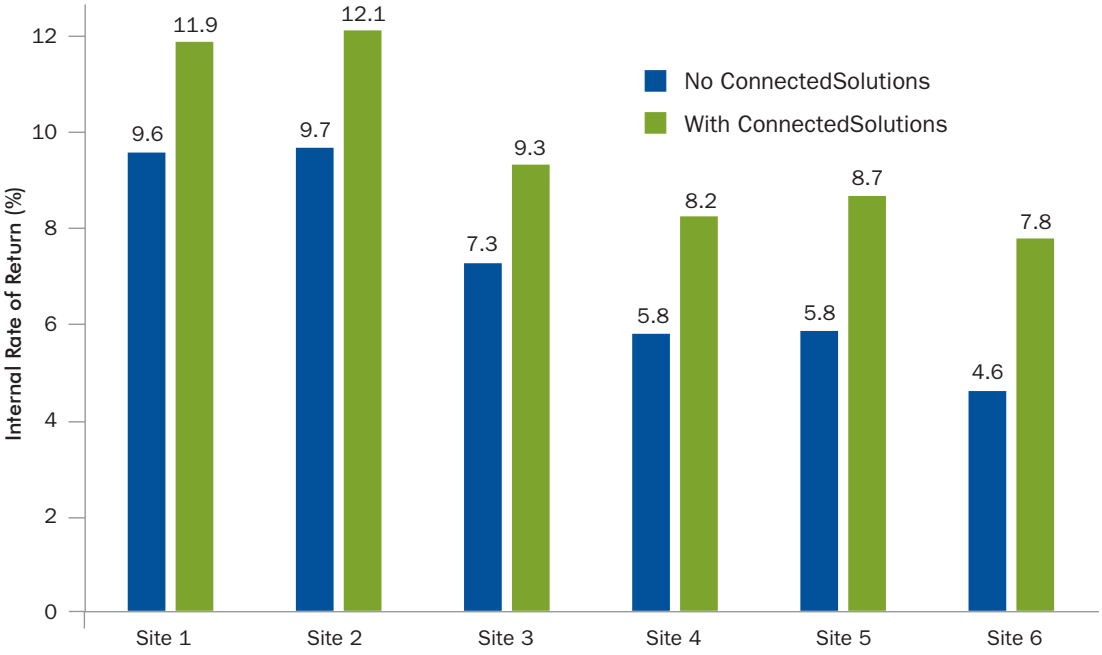
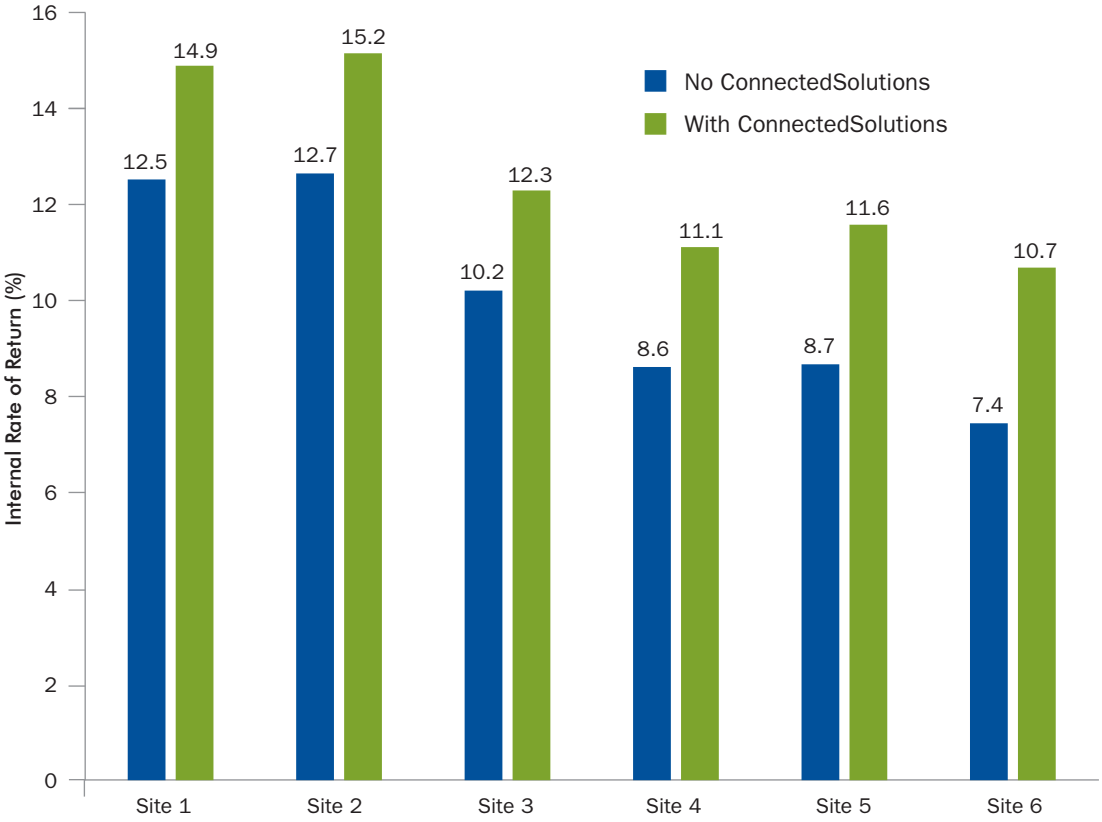


FIGURE 1B

Internal Rate of Return (Taxable Entity)



Internal rate of return (IRR) results for solar+storage systems at six Massachusetts multifamily affordable housing properties over a 25-year project period. The solar+storage systems at each site were optimized for two economic scenarios, either with the ConnectedSolutions program (green bars) or without ConnectedSolutions (blue bars), and two ownership scenarios: ownership by a nonprofit, tax exempt entity (Figure 1A) and ownership by a for-profit, taxable entity able to take advantage of federal tax credits (Figure 1B).

FIGURE 2A

Net Present Value (Tax Exempt Entity)

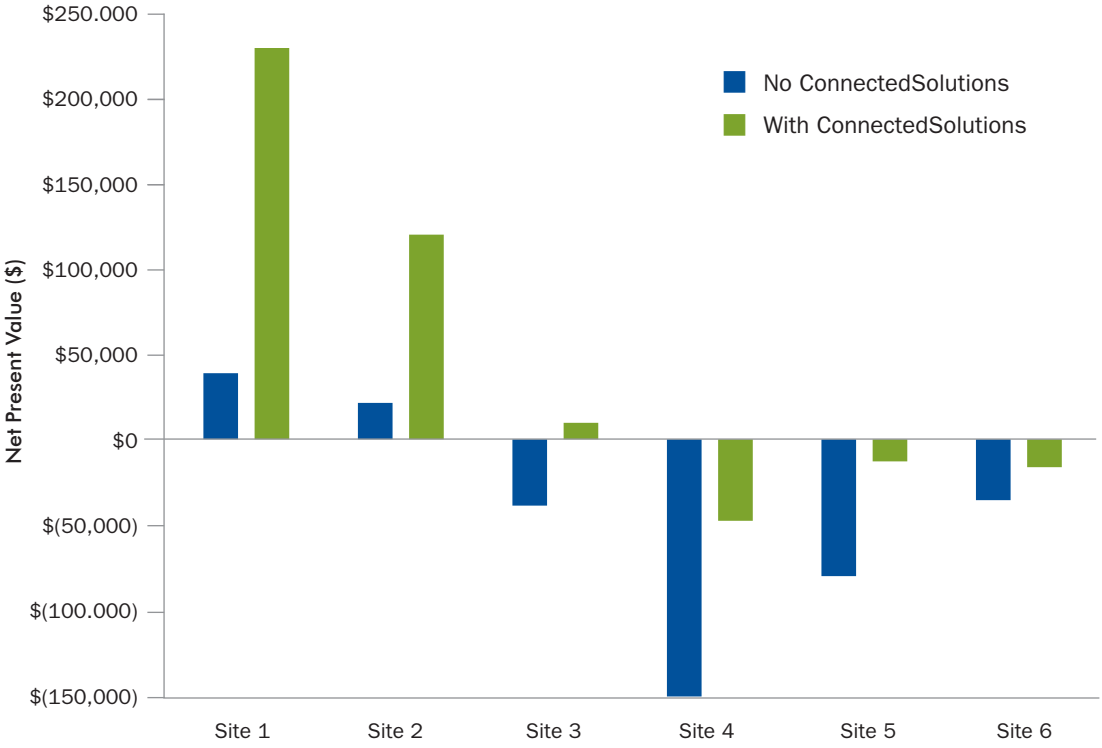
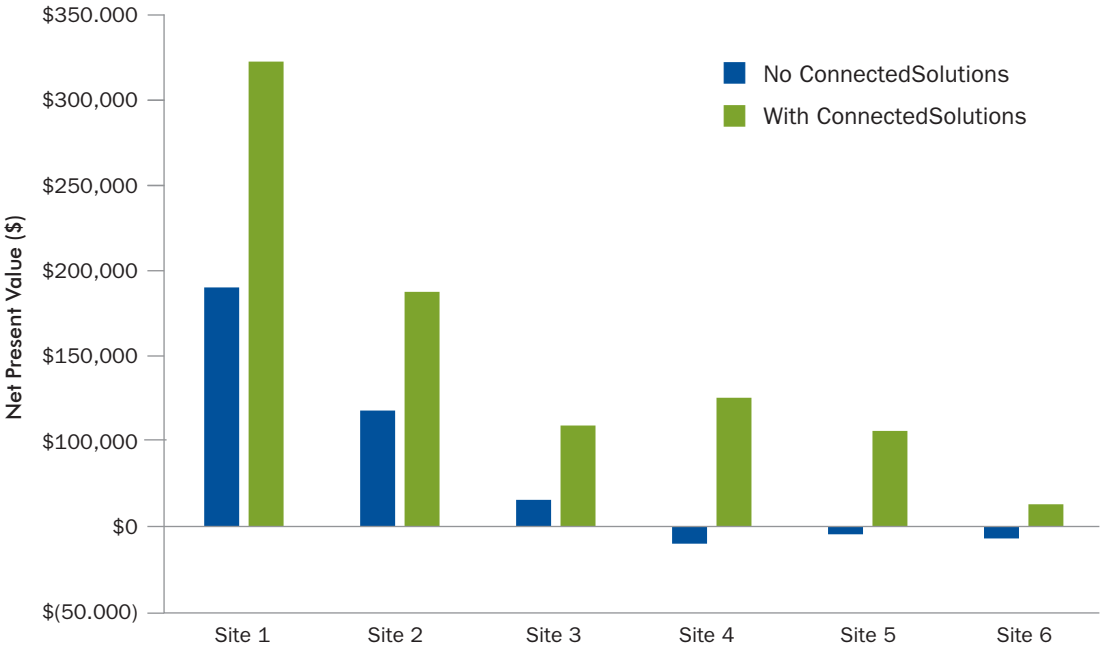


FIGURE 2B

Net Present Value (Taxable Entity)



Net present value (NPV) results for solar+storage systems at six Massachusetts multifamily affordable housing properties over a 25-year project period at a discount rate of 9 percent. The solar+storage systems at each site were optimized for two economic scenarios, either with the ConnectedSolutions program (green bars) or without ConnectedSolutions (blue bars), and two ownership scenarios: ownership by a nonprofit, tax exempt entity (Figure 2A) and ownership by a for-profit, taxable entity able to take advantage of federal tax credits (Figure 2B).

FIGURE 3A

Simple Payback Period (Tax Exempt Entity)

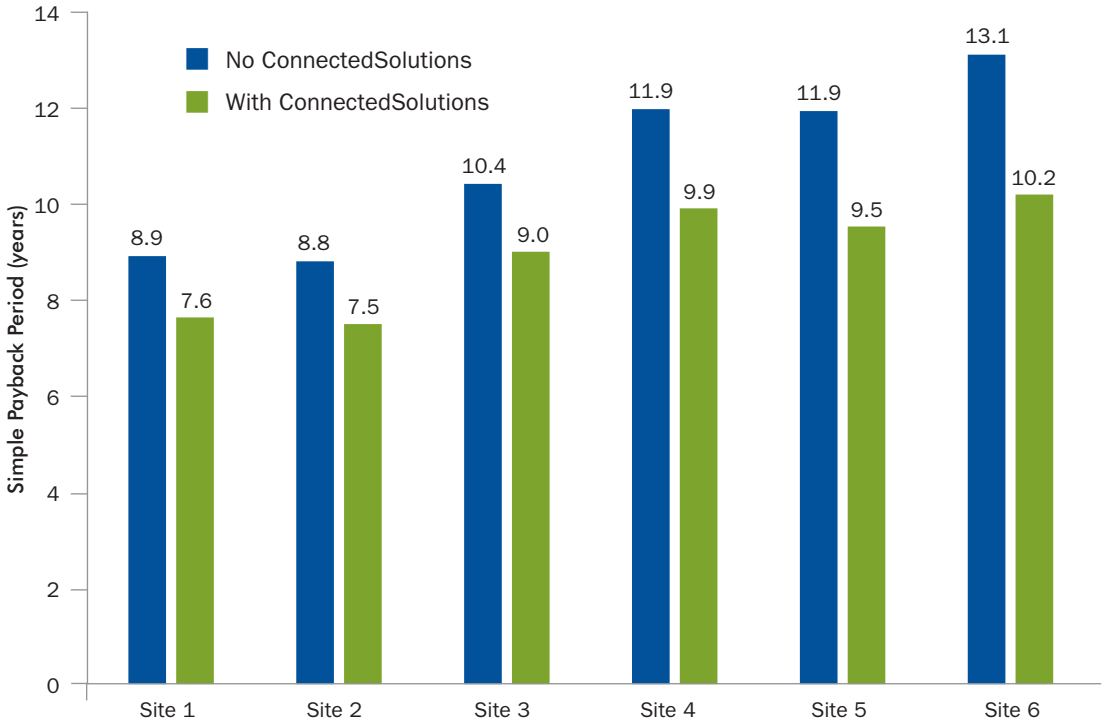
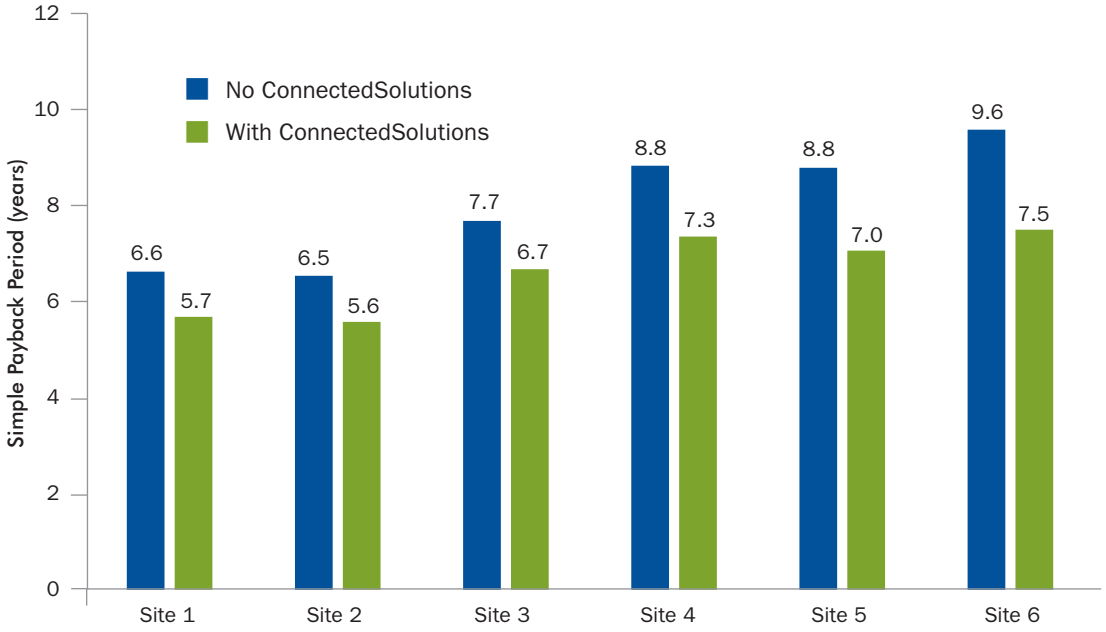


FIGURE 3B

Simple Payback Period (Taxable Entity)



Simple payback period (SPP) results for solar+storage systems at six Massachusetts multifamily affordable housing properties. The solar+storage systems at each site were optimized for two economic scenarios, either with the ConnectedSolutions program (green bars) or without ConnectedSolutions (blue bars), and two ownership scenarios: ownership by a nonprofit, tax exempt entity (Figure 3A) and ownership by a for-profit, taxable entity able to take advantage of federal tax incentives (Figure 3B).

iStockphoto/Denis Tangney, Jr.

Conclusion

The results of this study clearly demonstrate that the Massachusetts ConnectedSolutions program improves the financial feasibility of developing solar+storage projects at multifamily affordable housing properties, regardless of the size of the property, how it uses energy, the utility providing its electricity, or the structure of its electric rate tariff. The findings provide important evidence for how a program can be designed to help support the more equitable deployment of battery storage resources to serve all populations. This is particularly true for properties like affordable housing that may want to realize the resilience benefits of solar+storage to protect vulnerable populations but may not have energy consumption patterns that favor demand charge management, which has historically been the most widely available economic benefit from battery storage.

The analysis results point to several key aspects of ConnectedSolutions that could boost solar+storage deployment in affordable housing and similar types of community-serving facilities:

- ConnectedSolutions resulted in stronger economics for all sites analyzed, in several cases making battery storage economical at properties where it would not otherwise be financially viable.
- By providing five-year contracts and demand periods based on utility signals rather than customer predictions, ConnectedSolutions improves the financeability of solar+storage projects. While financial entities may be hesitant to invest in projects where the economics depend on varying and often unpredictable site-specific demand charge savings, the multi-year certainty of ConnectedSolutions and security of a utility-backed revenue stream make a project a much more bankable opportunity.
- Because the program is tied to regional demand, not site-specific demand, and because it rewards customers for power exported to the grid as well as for onsite load reduction, ConnectedSolutions allows for the development of larger battery systems. In addition to greater financial benefits, these larger battery systems could be used to power more critical loads over a longer period of time to keep essential services running during a power outage.[9]
- Unlike tax incentives, the benefits of ConnectedSolutions are accessible to tax exempt entities, which is pivotal for catalyzing greater battery storage investments by nonprofit entities, such as affordable housing providers, community-based organizations, and local governments.
- ConnectedSolutions results in customer battery systems being dispatched at more beneficial times for the grid as a whole, thereby benefiting all ratepayers and not simply the sites at which they are hosted, democratizing the benefits of energy storage.

The program's focus on regional demand and predictable, stable returns helps to reduce the risk of battery storage investment for system owners and shares the benefits of those investments across many parties. In addition to the grid benefits and economic returns ConnectedSolutions can deliver, it is critically important for the financial viability of solar+storage projects designed for energy resilience, which are often not financially supported by battery savings achievable through demand charge management alone.

None of these factors will guarantee that the introduction of a program like ConnectedSolutions will suddenly make solar+storage an attractive investment for all multifamily affordable housing properties or other types of facilities. However, it strongly suggests that a program with similar elements could radically improve the economic viability of solar+storage projects across a wide spectrum of facility types by freeing property owners from a dependence on site-specific conditions. Because of this, it is recommended that state policymakers interested in accelerating the deployment of customer-sited solar+storage, while also improving the equitable distribution of battery storage resources, explore the implementation of a program like ConnectedSolutions. For more detailed information about how to implement such a program, see *ConnectedSolutions: A New State Funding Mechanism to make Battery Storage Accessible to All* at www.cleanegroup.org/publications-library.

ENDNOTES

1 See the Resilient Power Project (*www.resilient-power.org*) for more information about Clean Energy Group's efforts to enable greater solar and battery storage access among low-income communities and communities of color.

2 Versions of the ConnectedSolutions program have also been adopted in Rhode Island, Connecticut, and New Hampshire, and similar programs have been proposed in other states, such as New Jersey and Virginia.

3 Todd Olinsky-Paul, "Energy Storage: The New Efficiency—How States Can Use Energy Efficiency Funds to Support Battery Storage and Flatten Costly Demand Peaks," *Clean Energy Group*, April 2019, *www.cleanegroup.org/wp-content/uploads/energy-storage-the-new-efficiency.pdf.*

4 "Massachusetts Battery Storage Measures: Benefits and Costs," *Applied Economics Clinic,* July 2018, *www.cleanegroup.org/ceg-resources/resource/massachusetts-battery-storage-measures-benefits-and-costs*.

5 The combination of battery storage and renewable generation can often serve as a viable, cost-effective alternative to peaker power plants. To learn more about efforts to replace peaker power plants with batteries and renewables, see Clean Energy Group's "Phase Out Peakers" initiative at *www.cleanegroup.org/ceg-projects/phase-out-peakers*.

6 Hourly load data was not available for five of the six sites. For these sites, usage data from monthly utility bills was scaled to hourly load data using either commercial reference building load profiles from the U.S. Department of Energy's buildings database or load profiles from similar facilities within the same region.

7 For more information about demand charges and how energy storage can reduce demand-related utility charges, see "An Introduction to Demand Charges" at *www.cleanegroup.org/ceg-resources/resource/demand-charge-fact-sheet*.

8 When paired together, both solar PV and battery storage are eligible for the federal investment tax credit (ITC). Households and organizations that have enough taxable income are eligible for a 26 percent investment tax credit to offset the installed cost of a solar installation and related hardware, including battery storage. For storage to be eligible for the ITC at a commercial property, the battery system must be primarily charged by onsite solar (at least 75 percent of the time).

9 Configuring a battery system to provide backup power to a facility typically involves added design complexities and additional project costs that were not considered in this analysis.

Appendix: Techno-Economic Modeling Inputs and Assumptions

The following section details relevant inputs and assumptions used in modeling the technical and economic feasibility of solar PV and battery storage for the six multifamily affordable housing properties assessed in this report.

The analysis uses the Redcloud tool developed by muGrid Analytics (*https://mugrid.com/energy-optimization-redcloud-mugrid-analytics*). Redcloud is a design and dispatch optimization platform that models the performance of a combination of distributed generation and energy storage assets within the specific conditions of a site and the utility serving the site. Redcloud identifies the optimal mix of assets, sizing, and operating characteristics to meet the host site's goals to minimize life cycle cost (LCC) of energy over a specified period including capital costs (equipment, installation, replacement), operating costs (fuel, maintenance, service), utility bill savings, revenue from incentives, and revenue from tax benefits. The model calculates and maximizes net present value (NPV) as the difference between current case LCC and base case LCC. Redcloud determines optimal sizing and dispatching of energy assets that maximizes NPV. Other non-financial goals and constraints impact design solutions selected but are not explicitly assigned financial values in the model.

General inputs and assumptions

- *Analysis period*: 25 years
- *Discount rate:* 9%
- *Utility tariff escalation rate:* 3%
- *Tax rate:* 21%

Solar inputs and assumptions

- *Solar system installed cost:* $3.00 per watt
- *Inverter replacement:* $44 per kilowatt (occurs in year 16)
- *Operations and maintenance:* $20 per kilowatt-year
- *Annual solar performance derate:* 0.7% per year

Battery storage inputs and assumptions

- *Battery storage system installed cost:* $1,000 per kilowatt-hour (lithium-ion batteries)
- *Battery replacement:* $150 per kilowatt and $100 per kilowatt-hour (occurs in year 11)
- *Operations and maintenance:* $5.63 per kilowatt-year
- *Battery control software:* $2,500 per year
- *Round-trip efficiency:* 90%

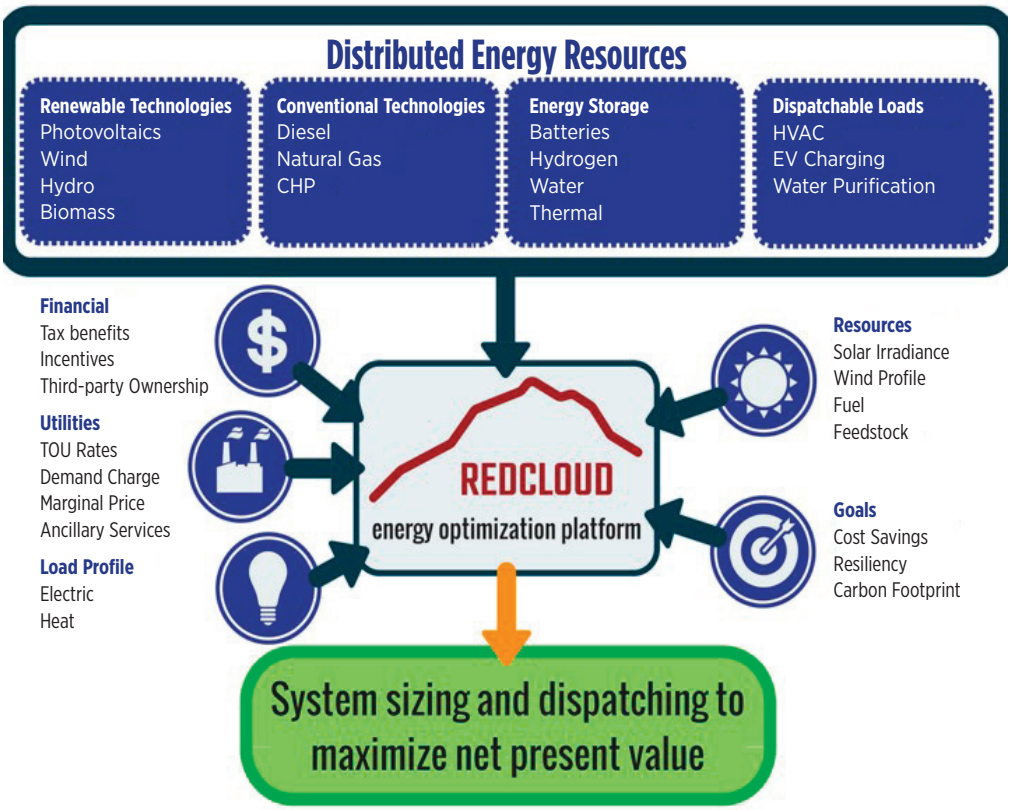
APPENDIX TABLE 1

Solar Massachusetts Renewable Target (SMART) Program Incentives

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
SMART Block	4	4	4	4	6	6
Base Compensation	$0.12	$0.12	$0.11	$0.10	$0.05	$0.05
Location Based Adder (Roof)	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02
Off-taker Based Adder (Low-income property)	$0.03	$0.03	$0.03	$0.03	$0.03	$0.03
Storage Adder	$0.04	$0.04	$0.04	$0.03	$0.04	$0.04
Total SMART Incentive	**$0.21**	**$0.21**	**$0.20**	**$0.18**	**$0.14**	**$0.14**

Programs and incentives

- *Federal Investment Tax Credit (ITC):* 26%
- *Modified Accelerated Cost Recovery System (MACRS):* 100% Bonus



The analyses assume that each site participates in the ConnectedSolutions Winter and Summer Daily commercial programs. The model assumes that the maximum number of events will be called each year and that the battery fully participates in each event. This approach yields the upper limit of what the program can generate in revenue and the upper constraint on required battery performance throughout each period.

While participation in ConnectedSolutions does not require it, participants may engage the services of a curtailment service provider (CSP) to facilitate registration and participation in the program. A CSP will make sure the participating battery storage system meets the program's metering and reporting requirements. Organizations engaging a CSP will typically split their incentive payments with the CSP under a negotiated contract. As ConnectedSolutions is still a relatively new program, the terms of these splits have not yet been standardized. The analyses assume a software driven approach with ongoing, incremental operating expenses for ConnectedSolutions instead of working with a CSP.

ConnectedSolutions contracts are currently five years in duration, well short of the 25-year project life used for the analyses. The analyses assume that the ConnectedSolutions program will be extended throughout the 25-year period and that the battery system will continue to participate in the program at the existing level of compensation rates, with no escalator.

APPENDIX TABLE 2

ConnectedSolutions Program Details and Assumptions

	Winter	Summer Targeted	Summer Daily
Projected number of events	4–6	2–8	30–60
Events assumed for analysis	6	8	60
Payment	$50/kW	$100/kW	$200/kW
Months	Dec–Mar	Jun–Sep	Jun–Sep
Days	M–F	M–F	M–F
Time	2–7 PM	2–7 PM	2–7 PM
Estimated event length	3 hours	3 hours	2-3 hours
Event length assumed for analysis	3 hours	3 hours	3 hours

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Seth is Vice President and Project Director for Clean Energy Group, overseeing projects ranging from customer-sited solar and battery storage to the replacement of power plants with clean technologies. Seth works with policy makers, project developers, industry, advocates, and community and environmental justice groups to advance clean energy policies and projects, with a focus on achieving greater access to solar and battery storage technologies for underserved communities. Much of his work pertains to the research and reporting of energy storage technologies, policies, and supporting market structures. Prior to joining CEG, Seth served as a Sustainable Energy Fellow with Union of Concerned Scientists and worked with Maine Clean Communities to help advance clean transportation initiatives. Seth holds a M.S. in Civil & Environmental Engineering from Stanford University, and a B.S. in Geosciences from the University of Southern Maine.

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Travis is Chief Technology Officer at muGrid Analytics, an owner's advisory and project development firm focused on delivering maximum economic return for clients' energy investment dollar. muGrid serves micro- and minigrid clients in the commercial and industrial sector and in the developing world. Though he was formally trained as an integrated circuit designer, he has spent most of the past decade helping to solve the world's energy challenge. He joined the National Renewable Energy Laboratory in 2010 and proceeded to reinvent their approach to modeling renewable energy systems. He pioneered a purely quantitative approach to analyzing and optimizing the costs and benefits of solar, wind, biomass, waste-to-energy, and other renewable technologies. His innovative research in this field led to him creating the REopt tool. Dr. Simpkins holds a S.M. and Ph.D. in Electrical Engineering and Computer Science from the Massachusetts Institute of Technology, a certificate of Financial Engineering from the MIT Sloan School of Management, and a B.S. in Electrical Engineering and Applied Physics from Case Western Reserve University. He is a Senior Member of the IEEE and has published numerous papers in the fields of energy system optimization, applied optics, and integrated circuits.

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Amy is Chief Executive Officer at muGrid Analytics. Prior to joining muGrid, Amy was an engineer and spacecraft systems architect with Lockheed Martin, where she worked on advanced R&D, design integration, and flight operations for critical spacecraft missions. Her technical expertise includes system and software architecture, system-level performance modeling, and design tradespace analysis. Amy has also provided independent strategic vision consulting to startups and small businesses. Amy holds an M.S. in Astronautical Engineering from the University of Southern California and an S.B. in Aeronautics and Astronautics from the Massachusetts Institute of Technology.

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Clean Energy Group (CEG) is a leading national, nonprofit advocacy organization working on innovative policy, technology, and finance strategies in the areas of clean energy and climate change.

CEG's energy storage policy work is focused on the advancement of state, federal, and local policies that support increased deployment of energy storage technologies. Battery storage technologies are critical to accelerate the clean energy transition, to enable a more reliable and efficient electric power system, and to promote greater energy equity, health, and resilience for all communities.

Learn more about Clean Energy Group and its Energy Storage Project at *www.cleanegroup.org/ceg-projects/energy-storage-policy*.

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