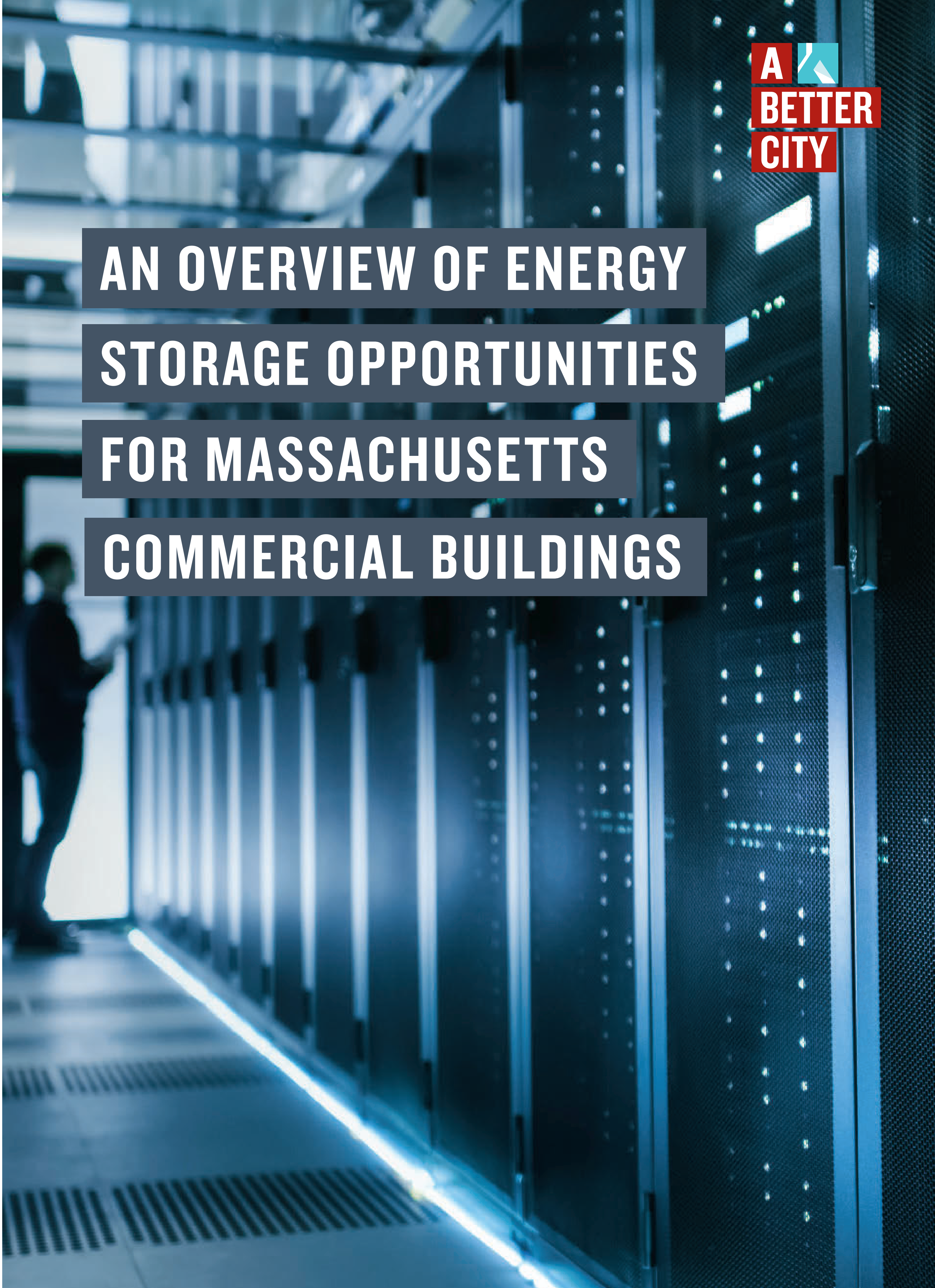
OVERVIEW APRIL 2018

A BETTER CITY

AN OVERVIEW OF ENERGY STORAGE OPPORTUNITIES FOR MASSACHUSETTS COMMERCIAL BUILDINGS



ACKNOWLEDGMENTS

This joint A Better City/Boston Green Ribbon Commission publication would not be possible without generous funding support from the Barr Foundation.

BOSTON Green Ribbon COMMISSION | Commercial Real Estate Working Group

REPORT TEAM

A Better City
- Yve Torrie

Meister Consultants Group, A Cadmus Company
- Will Hanley
- Kathryn Wright

REVIEWERS

- Ward Bower, Ward Bower Innovations LLC
- John Cleveland, Boston Green Ribbon Commission
- Meredith Hatfield, The Barr Foundation
- Lars Lisell, Resilient Energy Systems, National Renewable Energy Laboratory
- Seth Mullendore, Clean Energy Group
- Galen Nelson, Massachusetts Clean Energy Center
- Kavita Ravi, Massachusetts Clean Energy Center

To view a hyperlinked version of this report online, go to http://www.abettercity.org/assets/images/An_Overview_of_Energy_Storage_Opportunities.pdf

Design: David Gerratt/NonprofitDesign.com

CONTENTS

A BETTER CITY

A Better City is a diverse group of business leaders united around a common goal—to enhance Boston and the region's economic health, competitiveness, vibrancy, sustainability and quality of life. By amplifying the voice of the business community through collaboration and consensus across a broad range of stakeholders, A Better City develops solutions and influences policy in three critical areas central to the Boston region's economic competitiveness and growth: transportation and infrastructure, land use and development, and energy and environment.

AN OVERVIEW OF ENERGY STORAGE OPPORTUNITIES FOR MASSACHUSETTS COMMERCIAL BUILDINGS

INTRODUCTION

Energy storage has come to the attention of building owners around the country because of the cost savings it delivers, as well as the range of services and benefits it can provide to facilities and the broader electric grid. Energy storage deployment has grown exponentially in the United States over the past several years. Continued rapid growth is anticipated as the market is estimated to grow to nine times its current size over the next five years.[1] Many businesses are benefiting from this growth, in terms of both cost savings and energy resiliency.

Storage deployment has been driven by policies, incentives, and cost declines for certain battery chemistries. (For example, prices for lithium ion batteries—one of the most popular types of storage available—declined 73% between 2010 and 2016.)[2] These favorable conditions resulted in a 46% year-over-year growth between Q3 2016 and Q3 2017 for a diverse range of energy storage projects serving utilities as well as residential and commercial customers.

In the United States, by the end of 2017, deployed energy storage was estimated to be 215 megawatts (MW) and 335 megawatt-hours (MWh), versus

STORAGE DEPLOYMENT HAS BEEN DRIVEN BY POLICIES, INCENTIVES, AND COST DECLINES FOR CERTAIN BATTERY CHEMISTRIES.

60 MW and 55 MWh by the end of 2013.[3] In strong state markets like those of California and New York, energy storage economics are driven by a mix of state incentives, policy targets, demand-charge savings, and opportunities to provide "grid services."[4] In certain utility territories, demand charges can account for between 30 and 70% of customer bills.[5]

Massachusetts is on the verge of capturing the benefits of storage; the factors that have allowed California and New York to support vibrant storage market growth are now—or will soon be—present in Massachusetts. Both California and New York have high commercial demand charges; those within metro Boston can be equally high and make up most of a building's electric bill. A common metric used to determine the cost-effectiveness of battery energy storage for demand-charge management is $15/kilowatt (kW). In Boston, demand charges can often exceed this number.[6,7,8]

Generally, energy storage supports the largest demand-charge reductions at facilities with high peak loads relative to average usage, such as restaurants and commercial office space. When paired with on-site generation, such as solar photovoltaics (PV) or combined heat and power (CHP), energy storage can be cost-effective for a broad range of commercial facilities and energy profiles. When not paired with onsite generation, energy storage can be cost-effective in some cases, depending on the facility load type.[9] As demand charges increase, storage cost-effectiveness, with or without on-site generation, also increases. Depending on demand rates and building energy profiles, savings on electric bills from energy storage can yield payback periods ranging from 5 to 12 years.[10] Payback periods will vary by utility territory, technology employed, and revenue streams accessed. Existing commercial demand-charge rates in Massachusetts may increase, depending on the outcome of ongoing utility rate proceedings. Residential demand charges have been approved and were put into place at the beginning of 2018.[11]

States with a significant number of storage projects have incentives and supportive policies at the state and/or utility level. Massachusetts is currently preparing to launch several such policies and incentives. Under the new Solar Massachusetts Renewable Target (SMART) solar incentive program, expected to launch in the summer of 2018, solar PV paired with energy storage will receive a larger incentive than solar alone.[12] In addition, the Massachusetts Department of Public Utilities has approved a series of demand-management pilots proposed by Eversource, which will provide direct incentives to battery and thermal storage systems that provide demand-management support to the electricity distribution system.[13]

At the state level, the Energy Storage Initiative created by Governor Baker's administration has established a policy target of 200 MWh of storage by 2020. The Massachusetts Department of Energy Resources (DOER) is investigating the potential to meet this target through the state's Alternative Portfolio Standard, which would provide performance-based incentives.[14] The state has also supported storage deployments through the Community Clean Energy Resilience Initiative (CCERI) and the Advancing Commonwealth Energy Storage (ACES) programs. These policies and programs are an initial step in supporting energy storage deployment in the state; market growth could be further enhanced through storage incentives or procurement targets for utilities, as has been the case in California. (The section titled "Incentives and Support for Project Implementation" offers further details on storage programs.)

Existing and developing programs create a unique market opportunity for commercial energy storage. Planning or assessing the feasibility of such projects can be challenging, however, due to the diversity of energy storage technologies and their functionalities or "use cases."[15] For example, an energy storage installation used for demand-charge reduction will have different sizing, feasibility requirements, and

STATES WITH A SIGNIFICANT NUMBER OF STORAGE PROJECTS HAVE INCENTIVES AND SUPPORTIVE POLICIES AT THE STATE AND/OR UTILITY LEVEL.

cost considerations than one used for backup power. The appropriate energy storage technology, project applications, and energy savings will be highly dependent on each facility's energy use profile, utility rates (including demand charges), and the existence of on-site generation.

This document offers a useful introduction to key concepts; interested parties, however, should consult with industry professionals or state technical assistance services to assess technical feasibility and system economics in greater detail.[16]

ENERGY STORAGE HISTORY

Some energy storage technologies, such as utility-scale pumped hydro, have served the electric grid since the 1920s, but have become less popular over time due to siting and environmental issues.[17] Distributed, grid-connected energy storage at customer sites is a newer storage technology that has become more prevalent as battery costs have declined. Over the past decade, battery and thermal storage have been used more frequently in commercial buildings (see Table 1 for more information on energy storage types).[18,19,20] Commercial energy storage applications have grown rapidly over the past several years as a result of strong system economics, combined with state policies and incentives.[21] In certain markets, such as California and New York, quick payback periods—ranging from 4.2 to 8 years—have enabled many commercial properties to invest in storage systems.[22,23,24] Nationally, in addition to having been deployed for commercial buildings, energy storage has been successfully deployed for residential and industrial customers, distribution utilities, and wholesale markets.

ENERGY STORAGE TYPES AND TERMINOLOGY

BEHIND-THE-METER VERSUS FRONT-OF-THE-METER

There are two possible placements of energy storage in buildings: behind-the-meter (BTM) and front-of-the-meter (FTM). Positioning determines how the energy is used, and how the use is quantified. BTM storage is directly connected to a building's electrical infrastructure. FTM storage is linked only to the electric grid, and not to the building's electrical infrastructure. Most commercial installations, particularly those installed to capitalize on demand-charge reductions, are BTM systems. In either case, battery energy storage systems are usually bi-directional, to allow the system to switch between use cases and enable multi-directional electricity flow. The figure below illustrates the two layouts; the "Services and Benefits" section provides further information on various use cases.

KILOWATTS AND KILOWATT-HOURS

Energy storage is commonly referred to in terms of both kilowatts (kW) and kilowatt-hours (kWh). (Smaller systems may use watts or watt-hours, and larger systems commonly use MW or MWh.) A kW is a measure of power and reflects the maximum rate at which a battery can supply electricity at a given moment. A kWh is a measure of the amount of energy or electricity that a battery can store (also referred to as storage capacity). Energy is expressed as the relationship between power and time:

Energy = Power × Time.

For example, a 2 kW/10 kWh-rated battery can discharge 2 kW of power for approximately five hours (2 kW x 5 hours = 10 kWh). That same battery can deliver 1 kW of power for 10 hours (1 kW × 10 hours = 10 kWh). The optimal power-to-capacity ratio will vary with the use case and chemistry of the battery deployed.

SERVICES AND BENEFITS

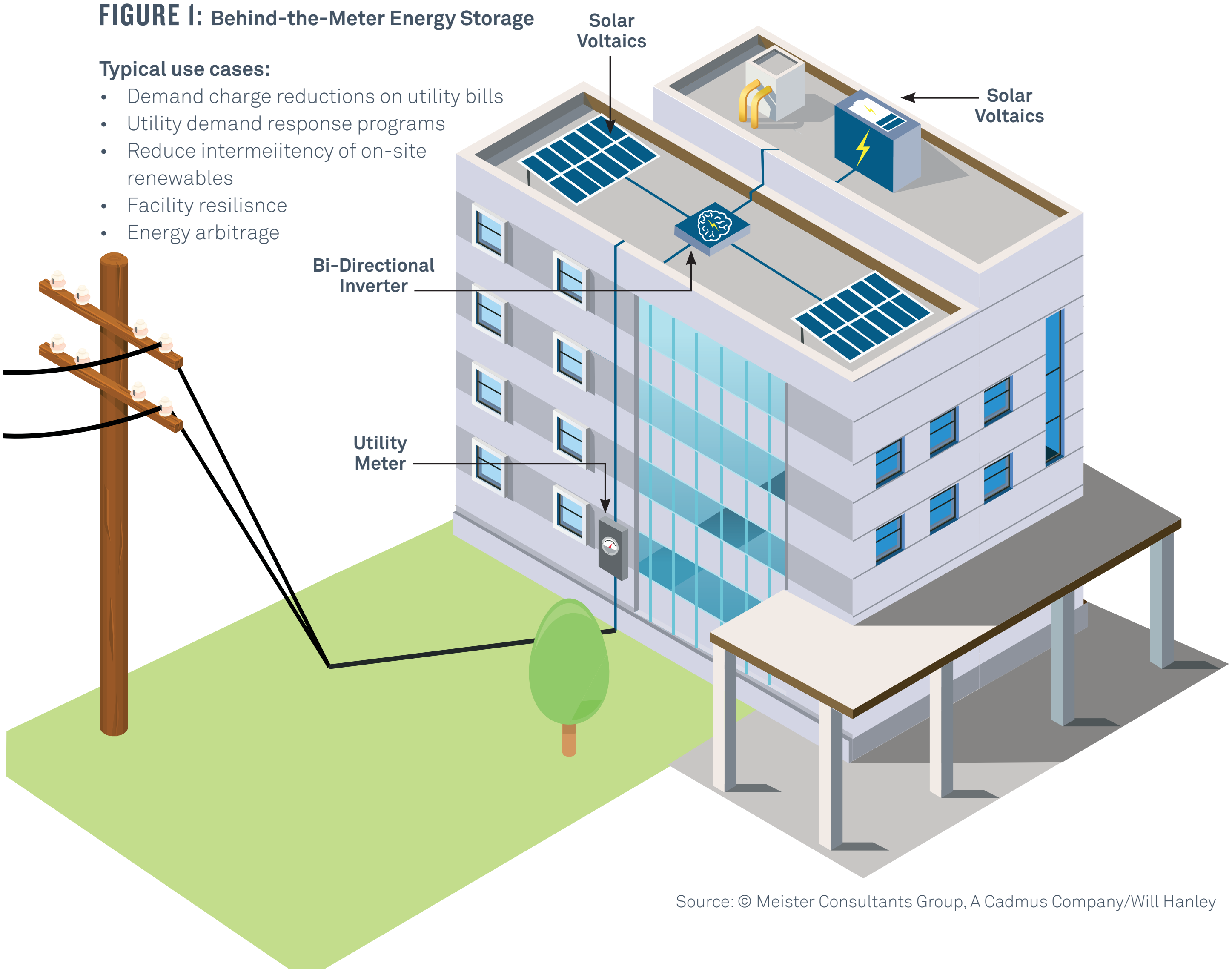
Storage can provide numerous services to building owners, local utilities, and wholesale market operators.

For building owners, storage can lower electric bills, increase the efficiency of on-site energy production, and strengthen facility-level energy resiliency. Storage also enables building owners to provide "grid services" to utilities and wholesale market operators; such services can improve grid efficiency, reduce green-

FIGURE 1: Behind-the-Meter Energy Storage

Typical use cases:

- Demand charge reductions on utility bills
- Utility demand response programs
- Reduce intermeiitency of on-site renewables
- Facility resilisnce
- Energy arbitrage



Source: © Meister Consultants Group, A Cadmus Company/Will Hanley house gas emissions, increase building- and grid-level resiliency, and enhance renewable energy integration.

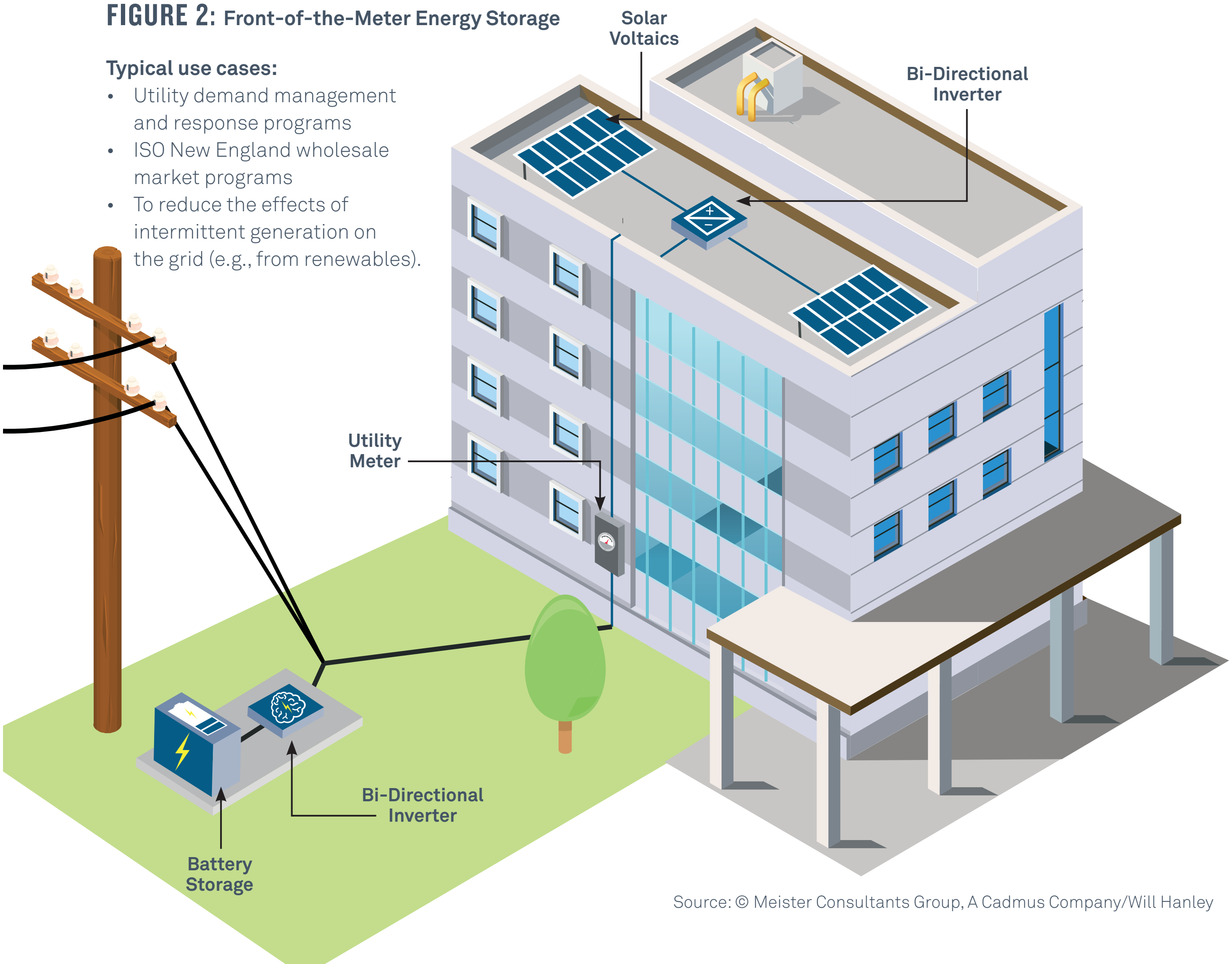
Today, cost savings and revenue generation, resilience, and grid and electricity optimization are the most common services and benefits available for storage at Massachusetts commercial and industrial (C&I) facilities.

Cost Savings and Revenue Generation

- **Demand-charge management.** Large energy users such as C&I facilities are typically charged for both power (kW) and energy (kWh) consumption by their electric service provider. Power consumption is typically calculated as the maximum amount of electricity a facility uses during a 15-minute interval for a given billing cycle. Demand charges are based on power consumption and appear as a line item on electric bills. As noted earlier, such charges commonly account for 30 to 70% of a building's electricity costs.[25] Battery storage can reduce demand charges by dispatching power as a building approaches peak demand. Massachusetts averages $19.14/kW of demand charges—a rate that can be even higher in Boston.[26,27] Given that $15/kW is considered the threshold for favorable energy storage economics, Massachusetts buildings may be prime candidates for this benefit.
- **Reduction of installed capacity charge.** Large energy users, such as hospitals and large commercial properties, may be subject to installed

FIGURE 2: Front-of-the-Meter Energy Storage

Typical use cases:
- Utility demand management and response programs
- ISO New England wholesale market programs
- To reduce the effects of intermittent generation on the grid (e.g., from renewables).



Source: © Meister Consultants Group, A Cadmus Company/Will Hanley

capacity (ICAP) charges from the New England Independent System Operator (ISO-NE), the wholesale market operator. These either appear as a line item on electric bills or are bundled with standard demand charges. Much like standard demand charges, ICAP charges are based on a customer's peak demand, as well as the system-wide grid peak. Coinciding customer and grid peak demands are used to calculate an "ICAP tag" that is the basis for these charges. By shifting energy consumption from the grid, energy storage can lower the ICAP tag, and thereby reduce ICAP charges.

- **Participation in demand response programs.** Utilities and wholesale market operators (commonly referred to as "independent system operators" or "regional transmission organizations") often offer demand response programs. Participants in these programs receive payments for reducing their electric consumption during times of high demand on the central grid, which frees up electricity for other customers. During high-demand times, battery storage can enable a facility to reduce consumption from the electric grid. Facilities can enroll in these programs individually or through an aggregator (e.g. EnerNOC).

- **Energy arbitrage.** Through the use of behind-the-meter energy storage, building owners subject to variable electricity pricing can leverage price gaps to reduce their electric bill. Charging the storage when electricity prices are low and discharging when prices are high shifts consumption to lower-cost electricity.

- **Other revenue generation opportunities.** In addition to demand response programs, new revenue generation opportunities are emerging from utility and wholesale operators. In Massachusetts, for example, storage paired with solar PV is now eligible to receive SMART program incentive payments.[28] New pilot programs, incentives, and regulatory changes that support greater revenue generation from energy storage are likely to enable Massachusetts to reach its 200 MWh target for storage.

Resiliency

- **Emergency power.** During a grid outage, battery storage can provide electricity to support critical loads such as lighting, refrigeration, communications, computers, and heating and cooling. Because of the cost and space requirements associated with energy storage, however, long-duration backup for high-power electric loads (e.g., more than two hours for large critical loads, or more than a few days for small loads) can quickly become uneconomical.[29] Hybrid backup power systems (e.g., solar PV, storage, and natural gas or diesel generators), which combine renewable and fossil fuel power generation sources, can yield savings by reducing fuel consumption and generator size. Additionally, pairing battery storage with solar PV can support emergency power for longer durations during daylight hours.

- **Uninterruptible power supply.** Like emergency power, an uninterruptible power supply (UPS) can provide backup power during grid outages. But whereas generators often take a few minutes to begin backup, UPSs respond almost instantaneously. Thus, they tend to be used in facilities such as data centers, which cannot experience even a momentary loss of electricity. Typically, UPSs provide power for seconds or minutes, to allow for the proper shutdown of equipment or for generators to come online.

Grid and Electricity Optimization

- **Renewables firming.** When co-located with on-site generation, energy storage can smooth (or "firm") electricity output, mitigating variability in electricity output due to changes in weather, temperature, shade, and other factors. Such systems may be particularly valuable to utilities in areas where renewables, such as solar PV, are in wide use.
- **CHP optimization**. Energy storage can be paired with CHP (combined heat and power) generation to support optimum efficiency and operation. Fossil-fuel and combustion-based generation often suffer from inefficiencies when electrical output is rapidly increased or decreased (a phenomenon known as "ramping"). Energy storage allows the CHP to generate electricity at a steady rate and avoid inefficiencies: when more output is required, energy storage can release energy; when excess power is generated, it can be directed to energy storage.
- **Power quality.** Manufacturing facilities and buildings with sensitive digital equipment can require consistent power quality. Variations in voltage supply can damage equipment or impede operations. Energy storage can provide fast-acting support to ensure that electricity from the grid meets the quality needed by end users.

Energy storage project developers look to maximize services and benefits for end customers, an approach commonly referred to as "value stacking." Due to the immaturity of the storage market in Massachusetts, few project developers are currently value stacking outside of pilot programs such as ACES. It is anticipated, however, that more value-stacking offerings and more opportunities for electric bill savings will be available for building owners in the coming year. These opportunities are due, in large part, to the start of the SMART program, high demand charges in the Eversource service territory, and the implementation of a voluntary storage procurement target for electric utilities.

TECHNOLOGY OPTIONS

Energy storage technologies are diverse, and the optimal technology will depend on space requirements and desired services or uses. Several technologies—such as flywheels, compressed air, and pumped hydro—are large-scale systems best suited to the utility or wholesale market. Currently, lithium ion and thermal storage are the most common technologies used by C&I facilities.[30,31] Options most suitable for C&I customers, the main focus of this document, are outlined in Table 1.

ENERGY STORAGE TECHNOLOGIES ARE DIVERSE, AND THE OPTIMAL TECHNOLOGY WILL DEPEND ON SPACE REQUIREMENTS AND DESIRED SERVICES OR USES. CURRENTLY, LITHIUM ION AND THERMAL STORAGE ARE THE MOST COMMON TECHNOLOGIES USED BY C&I FACILITIES.

TABLE 1: Storage Technology Options

	LEAD ACID[1]	LITHIUM ION[1]	FLOW[1]	THERMAL
Description	A form of electrochemical battery storage in which energy is stored and released by means of a chemical reaction. Typical types include sealed, flooded, valve-regulated, absorbent glass mat, and gel. Additives and differences in plate structure offer a variety of lifetime or performance advantages.	A form of electrochemical battery storage in which energy is stored and released by means of a chemical reaction. Many variations exist but typically contain lithium, cobalt, nickel, manganese, and aluminum.	A form of electrochemical battery storage that relies on a system of tanks, pumps, dissolved chemicals, and chemical reactions to charge and discharge electricity. This technology is in its earlier stages and has not reached the commercial scale of the others listed in this table.	Thermal storage stores energy (directly) or electricity (indirectly) in the form of heat or cold. By removing heat from or injecting heat into the storage container, thermal systems allow the warmth or cold to be used later. Among the many types are molten salt, hot water, and ice.
Typical Uses	Resiliency, limited grid support, peak load management, renewable energy firming, uninterruptible power supply (UPS)	Resiliency, grid support, peak load shifting, renewable energy firming, UPS	Resiliency, grid support, peak load shifting, renewable energy firming, UPS, bulk power management	Heating, ventilation, and air conditioning support; peak load shifting; onsite fossil fuel reduction (e.g. boiler), limited grid support, district heating
Cost	\$150–\$300/kWh	\$250–\$1,500/kWh	\$680–\$2,000/kWh	\$72–\$240/kWh[2,3]
Expected Life	5–10 years	10–15 years	10–20 years	20+ years[4,5]
Advantages	• Well-known, reliable technology. • Can withstand deep discharges, but at reduced life expectancy. • Relatively low cost.	• High energy density allows for high-power applications. • Can withstand deep discharges. • Has a high cycle life, allowing more intensive use or a longer life.	• Relatively safe. • Easy to scale up, and well suited for higher-capacity (duration) uses. • Long useful life.	• Low cost. • Flexible sizing. • Power and capacity ratings are independently scalable. • Leverages a mature technology base. • Can utilize waste industrial heat to improve efficiency.
Disadvantages	• Shortest life expectancy, due to lower number of useful cycles. • Lower energy density, meaning that more space will be required to provide the same amount of energy storage as other technologies.	• Can be more expensive than traditional energy storage systems. • Requires a sophisticated control system to mitigate fire risk (e.g., from thermal runaway). • Not readily recyclable and is a toxic waste issue.	• Relatively high cost. • Low efficiency (less than 70%). • Low energy density and thus can take up larger amounts of space. • High maintenance due to pumps. • Currently in the early stages of commercialization.	• Does not always directly address electric loads, because it typically covers heating and cooling. • Difficult to modularize for smaller installations.

Notes:

1. The Lead Acid, Lithium Ion, and Flow columns are based off a U.S. Department of Energy factsheet and Lazard Levelized Cost of Storage Report. Both are cited here: U.S. Department of Energy. "Resilient Solar Photovoltaics (PV) Systems." Available online: *https://nysolarmap.com/media/1451/dechardwarefactsheet.pdf*. Lazard. 2016. "Levelized Cost of Storage". Available online: *https://www.lazard.com/media/438042/lazard-levelized-cost-of-storage-v20.pdf*.
2. National Renewable Energy Laboratory. 2016. "Energy Storage Possibilities for Expanding Electric Grid Flexibility." Available online: *https://www.nrel.gov/docs/fy16osti/64764.pdf*.
3. Siciliano, John. 2015. *Washington Examiner*. "Energy Storage Finds a New 'Icy' Solution." Available online: *http://www.washingtonexaminer.com/energy-storage-finds-a-new-icy-solution/article/2568523*.
4. Calmac. "Frequently Asked Questions." Available online: *http://www.calmac.com/frequently-asked-energy-storage-questions*.
5. Ice-Energy. "Technology." Available online: *https://www.ice-energy.com/technology*.

ENVIRONMENTAL CONSIDERATIONS

Installing battery storage without co-located renewable energy resources does not necessarily yield environmental benefits. If the battery is charged by electricity from the central grid, the environmental impact will depend on the grid's mix of power sources. The primary environmental benefit of standalone energy storage is the reduction of the systemwide peak demand, which reduces the need for "peaker plants" (such plants can have higher emissions than other generation sources). Pairing storage with renewable energy sources, like solar PV, can provide greater environmental benefits by further reducing a facility's need to consume electricity from the central grid.

RESILIENCE CONSIDERATIONS

The average grid outage in the United States lasts approximately five hours, and the frequency of outages is increasing.[32,33] In 2000, the average number of U.S. grid outages per month was 2.5, versus more than 14 today.[34,35] To mitigate the risks associated with grid outages, battery storage can be a cost-effective, short-duration alternative (or supplement) to diesel or natural gas generators. Typically, relying solely on battery storage for grid outages of more than a few hours is uneconomical. For longer durations, hybrid systems that consist of solar PV, storage, and a generator are the most economical and provide the greatest resiliency for larger commercial loads. During normal grid operation, the solar PV and storage can provide energy savings. For shorter outages, the storage can provide fast-responding backup power. For longer outages, the solar PV and storage can supplement the generator and save fuel. Installing energy storage for resiliency requires additional equipment such as transfer switches, a critical-load panel, and specialized controls—added equipment that can increase project costs.[36]

To determine the economic viability of solar PV and storage for backup power, building owners and operators should first identify the electric loads critical to a facility's operation; the solar PV and battery storage should then be sized accordingly, to yield accurate estimates of costs. Owners and operators should then discuss opportunities for energy storage with energy services companies and/or project developers.

INCENTIVES AND SUPPORT FOR PROJECT IMPLEMENTATION

As noted earlier, the policy and incentive environment for storage in Massachusetts is dynamic and evolving. Table 2 highlights current opportunities; however, incentive and financing programs are expected to change over the next three to five years.

TABLE 2: Incentives and Support for Project Implementation

PROGRAM	HOST ENTITY	STATUS	ADDITIONAL INFORMATION
State Storage Target. In August 2016, the Massachusetts legislature called for the creation of an energy storage procurement target. The state has called for the electric utilities to meet a voluntary target of 200 megawatt hours (MWh) of energy storage by 2020. Beginning in 2017, each utility is required to submit an annual report on progress. Performance-based incentives for customers may result from this target.	State	Active	Energy Storage Initiative Webpage
Alternative Portfolio Standard. The Alternative Portfolio Standard (APS) is the proposed mechanism to support the 200 MWh target. The Massachusetts Department of Energy Resources (DOER) is tasked with determining whether energy storage should be included in the portfolio standard. Qualifying projects would receive performance-based alternative energy credits. The APS complements the Renewable Portfolio Standard by supporting alternative energy technologies, such as combined heat and power (CHP).	State	Pending	Evaluate Suitability of Storage in Alternative Portfolio Standard
Solar Massachusetts Renewable Target Program. The Solar Massachusetts Renewable Target (SMART) program is the next generation of solar incentives for Massachusetts. The program includes an additional incentive for solar PV systems that include energy storage. Under the proposed guidelines, storage systems that have a capacity of two to six hours and are equivalent to at least 25% of the solar PV system's capacity can receive incentives of up to $.0763/kWh.	State	Pending (Energy Storage Guidelines are undergoing public comment until 2/23/18)	SMART Program Energy Storage Guidelines
Massachusetts Property Assessed Clean Energy Program. The Massachusetts Property Assessed Clean Energy (PACE) program is a new, low-interest loan program hosted by Mass Development. The program utilizes a property lien as a repayment mechanism for energy investments. According to the draft program regulations, storage will be an eligible technology. The program is anticipated to launch in Q2 2018.	Mass Development	Pending	PACE Program Website
Third-Party Financing. To reduce the up-front cost of storage systems, many energy storage developers are offering third-party lease models. These models often use shared savings agreements to split the benefits of demand-charge reduction or demand response program payments between the financing entity and the host site.	Private providers	Active	Better Buildings Energy Storage Guide
Tax Incentives. Battery energy storage when paired with eligible renewable energy technologies qualifies for accelerated depreciation and a federal tax credit. The federal investment tax credit (ITC) supports combined solar + storage systems as long as 75% of the storage system is charged from the solar system rather than the grid. Until 2019, the ITC provides a credit for 30% of the cost of the system; the credit drops to 26% at the beginning of 2020, to 22% at the beginning of 2021, and steps down permanently to 10% at the beginning of 2022 (only commercial systems will be eligible for the 10% at this point). (Readers are advised to consult a tax professional for additional details.)	Federal	Active	Guidance for Tax Incentives for Storage and Solar+Storage systems
Commercial Solar and Storage Technical Assistance and Resource Hub. The Massachusetts Clean Energy Center (MassCEC) provides commercial property owners with free resources and technical assistance on issues associated with solar energy and storage.	MassCEC	Active	Commercial Solar Hub
Utility-Based Demand-Management Pilots. Every investor-owned utility in the state has developed pilot demand-management programs that rely on automated demand response programs and compensate host sites for energy reductions on a dollars-per-kW basis. The Department of Public Utilities recently approved Eversource's demand-management pilot program, which will leverage battery and thermal applications to lower the utility's peak demand. Utilities are expected to provide a wider range of demand-management offerings as part of their 2019–2021 Efficiency Plans.	Utilities	Pilots are ongoing; demand-management programs are pending.	Utility Demand Management Proposal Overview

— CONTINUED —

TABLE 2: **Incentives and Support for Project Implementation**

PROGRAM	HOST ENTITY	STATUS	ADDITIONAL INFORMATION
Advancing Commonwealth Energy Storage Grant Program. The Advancing Commonwealth Energy Storage (ACES) grant program is part of the state's Energy Storage Initiative, which is designed to encourage market development for storage technologies statewide. In 2018, the grant program provided $20 million to 26 demonstration projects throughout the state.	State	Closed	ACES Program Overview
Community Clean Energy Resiliency Initiative Grant Program. The Community Clean Energy Resiliency Initiative (CCERI) program was a multi-phase initiative launched by Massachusetts DOER to encourage public facilities to invest in energy resilience. The grants funded feasibility assessments and implementation support. (A final phase expanded the program to hospitals.)	State	Closed	CCERI Program Overview
Community Microgrid Program. The community microgrid program provided grants for feasibility assessments for multi-facility microgrids, which could include renewables, CHP, and energy storage. The projects had to be community led but could include commercial and residential property. The program is currently closed but may accept additional rounds of applicants in the future.	MassCEC	Closed	Community Microgrid Program
Commercial and Industrial Storage Feasibility Grants. To seed storage development at commercial and industrial facilities, MassCEC provided grants for feasibility assessments for combined solar and storage at manufacturing facilities.	MassCEC	Closed	Solar and Storage Site Assessment Program

TO DETERMINE THE ECONOMIC VIABILITY OF SOLAR PV AND STORAGE FOR BACKUP POWER, BUILDING OWNERS AND OPERATORS SHOULD FIRST IDENTIFY THE ELECTRIC LOADS CRITICAL TO A FACILITY'S OPERATION.

BOX 1: Advancing Commonwealth Energy Storage Program Grantees In Boston

The Massachusetts Advancing Commonwealth Energy Storage (ACES) grant program is part of the state's Energy Storage Initiative (ESI), which was created in 2015. The goal of the initiative is to spur statewide market development for storage technologies. In 2017, ACES provided $20 million in grants to 26 demonstration projects throughout the state. These demonstration projects showcase various applications of electrochemical, thermal, and other energy storage technologies for municipal and investor-owned utilities, commercial and residential facilities, and the wholesale market. The hope is that the projects will assist in commercializing energy storage applications, which can provide multiple revenue streams (or "value stacks") to host customers and the grid.

Among the ACES grantees are several members of the Boston Green Ribbon Commission and A Better City, including Boston Medical Center, the University of Massachusetts-Boston, and a collaboration between GE, AECOM, and Suffolk. The University of Massachusetts-Boston project emphasizes resilience, utility bill reductions, and capacity building and education to support energy storage technologies.

Source: Massachusetts Clean Energy Center. 2018. "Advancing Commonwealth Energy Storage: Awardee Summary." Available online: *http://files.masscec.com/Simplified%20Projects%20Summary_3.pdf.*

MARKET BARRIERS AND POLICY OPPORTUNITIES

The economics of energy storage have improved dramatically as technology costs have declined, and as barriers to participation in some energy markets have been removed. Many markets, however, including Massachusetts, still have only a small number of energy storage installations. The factors shaping this situation include:

- **Novelty.** Although newer chemistries have increased the potential to apply energy storage to daily energy needs, building and energy-industry professionals are still learning about energy storage applications and operating parameters. Thus, storage is less likely to be recommended as part of a suite of energy-improvement measures, whether those are undertaken by private-sector providers or in the context of state or utility programs.

- **Cost.** The costs of energy storage (particularly lithium ion batteries) have declined. Up-front costs can still be prohibitive, however, for many uses (see the "Services and Benefits" section). Based on project costs for commercial lithium-ion systems across the country, average system costs are $55,000 for a two-hour duration, 30 kW system.[37] By comparison, the cost estimate for a 30 kW solar PV system is $50,000.[38,39,40]

  To address the cost burdens, many developers are relying on shared savings, leases, and power purchase agreements. Survey research undertaken in New York State indicates that third-party agreements were used to finance approximately 50% of systems.[41] In other markets, however, third-party ownership has had a higher cost of capital than other financing models.[42]

- **Local regulations.** Local governments must permit, inspect, and approve any energy storage installations within their jurisdictions. For example, the systems must meet local siting requirements for indoor or outdoor installations. Host sites for storage systems also may have limitations on available, permittable space for energy storage that don't meet local jurisdictional requirements. Local governments are still familiarizing themselves with energy storage and developing appropriate regulations, such as fire and safety procedures. For this reason, the process of installing energy storage can be prolonged as local government procedures catch up with technology adoption.

- **Integration into policy.** Storage is a versatile resource that has the potential to provide multiple revenue streams to buildings and project developers. In some cases, however, policies and programs, whether intentionally or unintentionally, exclude energy storage systems. For example, the operating model for ISO-NE wholesale market programs is not well designed to

TABLE 3: Policy and Programmatic Actions to Support Energy Storage

PRIMARY ACTORS	CITY OF BOSTON	REAL ESTATE INDUSTRY	A BETTER CITY
Near Term (0–1 year)			
Expansion of the Eversource Demand Management Pilots in the 2019–2021 Three-Year Plans In New York, Con Edison's demand-management program provided strong incentives for the development of distributed storage projects within New York City.[43,44] Utility demand-management programs could be poised to play a similar role in Massachusetts. Although demand-management offerings are currently limited to small pilots, the Energy Efficiency Advisory Council is calling on utilities to include demand-management programs for all sectors within their 2019–2021 three-year efficiency plans, which are undertaken as part of the Mass Save program.[45] A Better City will continue to provide feedback on the importance of expanded demand-management programs. The Boston Green Ribbon Commission could also echo this message, as the three-year plans are being drafted throughout the year.		●	●
Education and Outreach on Emerging Commercial and Industrial Storage Opportunities Public and quasi-public agencies have launched or are developing programs to support commercial energy storage and other energy improvement projects, including the Solar Massachusetts Renewable Target (SMART) program, Massachusetts Property Assessed Clean Energy (PACE) program, and the Advancing Commonwealth Energy Storage (ACES) program. As findings from the demonstration projects become available and programs are finalized, A Better City and the Boston Green Ribbon Commission will continue to ensure that the commercial real estate sector is informed of available opportunities. The experiences of ACES grantees, for example, could yield guidance and best practices for participation in the wholesale market programs of New England Independent System Operator.			●
Medium Term (1–3 years)			
Commercial Sector Feedback on Demand-Management Programs Utilities are expected to develop demand-management programs for the commercial and industrial sector. Successful uptake will depend on the programs' suitability for various commercial building types. A Better City and the Boston Green Ribbon Commission can provide feedback on program design by hosting focus groups, reviewing program materials, and staying apprised of program progress through the Energy Efficiency Advisory Council.		●	●
Integrating Storage Readiness into Building Codes and Standards Echoing the findings of the State of Charge report, A Better City and the Boston Green Ribbon Commission believe that permitting, life safety, and building regulations must be responsive to the emergence of indoor and outdoor energy-storage systems.[46] Unclear state and local codes and regulations can delay approvals and create high barriers to entry for facilities that wish to install energy storage. As appropriate, A Better City will work with the Boston Green Ribbon Commission and city officials to advocate for better regulatory processes for energy storage.	●		●

accommodate smaller distributed storage resources, as it was intended to work with legacy pumped-hydro systems.[47] Additionally, behind-the-meter storage projects do not meet size requirements for some ISO-NE programs. The Federal Energy Regulatory Commission has required independent system operators across the country to review and update their policies to accommodate advanced energy storage.[48] Thus, it is expected that policies will evolve in the coming years.

City of Boston, state, and private sector leaders in Massachusetts can work together to address these challenges. Both Boston and the Commonwealth of Massachusetts have set ambitious greenhouse gas reduction goals for 2050. As intermittent renewable energy resources are more widely deployed to meet those goals, energy storage installations will become increasingly important, not only to meet City and state goals, but as a means of improving grid efficiency by reducing system peaks.[49] Further intelligent deployment of energy storage will also increase the resilience of critical facilities, commercial real estate assets, and the downtown Boston grid. In *State of Charge*, a report on storage market development across all sectors, the state details a range of policy options and next steps.[50] A number of these policies and programs are crucial to encouraging development of commercial energy storage within Boston. Table 3 outlines priority action items for the Boston commercial real estate sector.

Energy storage has the potential to be a disruptive yet accessible technology that can drive greenhouse gas reductions, increase energy savings, and improve the resilience of the built environment. The energy storage market has reached a turning point: many more technologies are now commercially available; they are also more affordable and cost-effective. In other states, owners and developers of commercial buildings have been first movers in the distributed storage market, taking advantage of economic opportunities and increasing their facilities' preparedness for climate change. The storage market in Massachusetts is developing rapidly, and the Boston commercial real estate community has an opportunity to demonstrate its leadership in the adoption of energy storage technology. In the immediate term, A Better City is committed to keeping its members informed about storage opportunities as they arise, and communicating with members about the progress and successes of storage demonstration projects. Collectively, the commercial real estate community can evaluate and leverage energy storage to make further progress toward energy conservation and broader sustainability goals.

ENDNOTES

1 GTM Research. December 2017. "U.S. Energy Storage Monitor, Year in Review Report: Executive Summary." Available for download online: https://www.greentechmedia.com/research/subscription/u-s-energy-storage-monitor.

2 Bloomberg New Energy Finance. July 2017. "Lithium-ion Battery Costs and Market." Available online: https://data.bloomberglp.com/bnef/sites/14/2017/07/BNEF-Lithium-ion-battery-costs-and-market.pdf.

3 GTM Research. December 2017. "U.S. Energy Storage Monitor, Year in Review Report: Executive Summary." Available for download online: https://www.greentechmedia.com/research/subscription/u-s-energy-storage-monitor.

4 National Renewable Energy Laboratory. 2017. "Identifying Potential Markets for Behind-the-Meter Battery Energy Storage: A Survey of U.S. Demand Charges." Available online: https://www.nrel.gov/docs/fy17osti/68963.pdf. See the "Services and Benefits" section for more information on demand charge reduction.

5 Ibid.

6 Eversource. 2018. "2018 Summary of Eastern Massachusetts Electric Rates for Greater Boston Service Area." Available online: https://www.eversource.com/content/docs/default-source/rates-tariffs/ema-greater-boston-rates.pdf?sfvrsn=c27ef362_14.

7 National Renewable Energy Laboratory. 2017. "Identifying Potential Markets for Behind-the-Meter Battery Energy Storage: A Survey of U.S. Demand Charges." Available online: https://www.nrel.gov/docs/fy17osti/68963.pdf, p. 7.

8 Clean Energy Group. 2017. "An Introduction to Demand Charges." Available online: https://www.cleanegroup.org/wp-content/uploads/Demand-Charge-Fact-Sheet.pdf.

9 Clean Energy Group and NREL. 2017. "Solar + Storage: Understanding Commercial-Scale Project Economics through Cost Modeling; Impact of Load Profile on Solar+Storage Economics." Available online: https://www.cleanegroup.org/ceg-projects/solar-storage-optimization/cost-modeling/#tab-id-7.

10 Ibid.

11 Massachusetts Department of Public Utilities. January 5, 2018. DPU 17-05-B. "Petition of NSTAR Electric Company and Western Massachusetts Electric Company, each doing business as Eversource Energy, Pursuant to G.L. c. 164, § 94 and 220 CMR 5.00 et seq., for Approval of General Increases in Base Distribution Rates for Electric Service and a Performance Based Ratemaking Mechanism." Available online: http://170.63.40.34/DPU/FileRoomAPI/api/Attachments/Get/?path=17-05%2f1705B_Order_1518.pdf.

12 Massachusetts Department of Energy Resources. 2018. "Development of the Massachusetts SMART Program." Available online: https://www.mass.gov/service-details/development-of-the-solar-massachusetts-renewable-target-smart-program.

13 Joint Utilities. December 2016. "Overview of Proposed/Approved Peak Demand Reduction Demonstration Projects." Available online: http://ma-eeac.org/wordpress/wp-content/uploads/Matrix-Memorandum-12-2-16.pdf.

14 Commonwealth of Massachusetts. 2018. "Energy Storage Initiative." Available online: https://www.mass.gov/energy-storage-initiative.

15 "Use case" is the term used by the energy industry to describe the various ways energy storage can serve as host site or grid. The term "value-stacking" is used when an energy storage system can provide multiple use cases.

16 Locally, the Massachusetts Clean Energy Center has launched a storage and solar technical assistance portal and service for commercial property owners. Nationally, the National Renewable Energy Lab has developed a ReOpt calculator (beta) for high-level feasibility assessments. A series of completed modeling results for commercial property types across the country is available online. The U.S. Department of Energy also has an Energy Storage Computational Tool for basic financial projections. Additionally, some private-sector providers provide calculators on their websites.

17 U.S. Department of Energy. "History of Hydropower." Available online: https://energy.gov/eere/water/history-hydropower.

18 Spector, Julian. Greentech Media. 2013. "How Does Thermal Storage Reach Scale?" Available online: https://www.greentechmedia.com/articles/read/how-does-thermal-energy-storage-reach-scale#gs.pfP_stw.

19 Grandview Research. 2015. "Advanced Energy Storage Systems Market Analysis by Technology and Segment Forecasts to 2022." Available online: https://www.grandviewresearch.com/industry-analysis/advanced-energy-storage-systems-market.

20 Wilson, Adam. GreenBiz. 2018. "Expect Strong Growth This Year for Commercial Storage." Available online: https://www.greenbiz.com/article/expect-strong-growth-year-commercial-energy-storage.

21 Greentech Media. 2017. "Q4 2017 U.S. Energy Storage Monitor." Available online: https://www.greentechmedia.com/research/subscription/u-s-energy-storage-monitor#gs.MHMGdKo.

22 Smart DG Hub. November 2017. "Marcus Garvey Apartments Microgrid." Available online: https://nysolarmap.com/media/1844/marcus-garvey_casestudy_917.pdf.

23 Krulewitz, Andrew, Saueregger, Sita, and De Chalendar, Jacques . July 2015. "Analytic Design Is the Key to Opening New Energy Storage Markets." Green Tech Media. Available online: https://www.greentechmedia.com/articles/read/Analytic-Design-is-Key-to-Opening-New-Energy-Storage-Markets#gs.9P5TrV0.

24 Lutton, J. and Sussman, M. September 2015. "Energy Storage 201: Commercial BTM Storage." Woodlawn Associates. Available online: https://woodlawnassociates.com/energy-storage-201/.

25 National Renewable Energy Laboratory. 2017. "Identifying Potential Markets for Behind-the-Meter Battery Energy Storage: A Survey of U.S. Demand Charges." Available online: https://www.nrel.gov/docs/fy17osti/68963.pdf. See the "Services and Benefits" section for more information on demand charge reduction.

26 Eversource. 2018. "2018 Summary of Eastern Massachusetts Electric Rates for Greater Boston Service Area." Available online: https://www.eversource.com/content/docs/default-source/rates-tariffs/ema-greater-boston-rates.pdf?sfvrsn=c27ef362_14.

27 National Renewable Energy Laboratory. 2017. "Identifying Potential Markets for Behind-the-Meter Battery Energy Storage: A Survey of U.S. Demand Charges." Available online: https://www.nrel.gov/docs/fy17osti/68963.pdf.

28 Massachusetts Department of Energy Resources. "Development of the Solar Massachusetts Renewable Target (SMART) Program." Available online: https://www.mass.gov/service-details/development-of-the-solar-massachusetts-renewable-target-smart-program.

29 Anderson, Kate et al. 2016. National Renewable Energy Laboratory. "New York Solar Smart DG Hub-Resilient Solar Project: Economic and Resiliency Impact of PV and Storage on New York Critical Infrastructure." Available online: https://www.nrel.gov/docs/fy16osti/66617.pdf.

30 Zipp, Katherine. 2017. Solar Power World. "Trending in Solar Storage: Flow Battery Technology Improving, but Lithium-Ion Still Rules." Available online: https://www.solarpowerworldonline.com/2017/06/trending-solar-storage-flow-battery-technology-improving-lithium-ion-still-rules/

31 Grand View Research. 2015. "Advanced Energy Storage Systems Market Analysis by Technology (Batteries, Flywheel, Thermal, Compressed Air, Molten Salt) and Segment Forecasts to 2022." Available online: https://www.grandviewresearch.com/industry-analysis/advanced-energy-storage-systems-market.

32 When major-event days are excluded (e.g., long-duration outages from natural disasters), the average outage in the United States is approximately two hours.

33 U.S. Energy Information Administration. 2017. "Electric Power Sales, Revenue, and Energy Efficiency Form EIA-861 Detailed Data Files." Available online: https://www.eia.gov/electricity/data/eia861/.

34 Data from the Inside Energy Grid Disruption Database ends June 30, 2014. Available online: http://insideenergy.org/2014/08/18/data-explore-15-years-of-power-outages.

35 Wirfs-Brock, Jordan. 2014. Inside Energy. "Power Outages on the Rise across the U.S." Available online: http://insideenergy.org/2014/08/18/power-outages-on-the-rise-across-the-u-s/.

36 Mullendore, Seth. 2018. National Renewable Energy Laboratory and Clean Energy Group. "Valuing the Resilience Provided by Solar and Battery Energy Storage Systems." Available online: https://www.cleanegroup.org/ceg-resources/resource/valuing-resilience-solar-battery-energy-storage/.

37 Mclaren, Joyce, et al. October 2016. National Renewable Energy Laboratory. "Battery Energy Storage Market Commercial Scale Lithium-Ion Projects in the U.S." Available online: https://www.nrel.gov/docs/fy17osti/67235.pdf.

38 This cost assumes a $0.10 increase in installed costs due to the solar tariff.

39 Pyper, Julia. 2017. Greentech Media. "The Trade Case Just Put $1 per Watt Solar Pricing Back Out of Reach." Available online: https://www.greentechmedia.com/articles/read/solar-trade-case-1-per-watt-section-201#gs.taUfFfk.

40 Appropriate sizing and ratios for solar PV or battery systems are highly dependent on building load and use case. System sizing is not necessarily 1:1; the comparison is provided to help illustrate relative costs.

41 Smart DG Hub. December 2015. Sustainable CUNY. "Summary of Results: Solar and Storage Cost Survey." Available online: https://nysolarmap.com/media/1449/dghubsolarandstoragecostsurveyresults.pdf.

42 Feldman, David, and Lowder, Travis. November 2014. National Renewable Energy Laboratory. "Banking on Solar: An Analysis of Banking Opportunities in the Distributed PV Market." Available online: https://www.nrel.gov/docs/fy15osti/62605.pdf.

43 Linares, Corinna. May 23, 2017. Electric Light & Power.com. "Con Edison to Let Energy Storage Systems Feed Power to the Grid." Available online: http://www.elp.com/articles/2017/05/con-edison-to-let-energy-storage-systems-to-export-to-power-grid.html.

44 Smart DG Hub. December 2015. Sustainable CUNY. "Summary of Results: Solar + Storage Cost Survey." Available online: https://nysolarmap.com/media/1449/dghubsolarandstoragecostsurveyresults.pdf.

45 Energy Efficiency Advisory Council. January 2018. "EEAC Draft Councilor Workshop Recommendations." Available online: http://ma-eeac.org/wordpress/wp-content/uploads/EEAC-Recs-1-30-18-clean.pdf.

46 Customized Energy Solutions et. al. July 2017. Massachusetts DOER and MassCEC. State of Charge," p. 174. Available online: http://www.mass.gov/eea/docs/doer/state-of-charge-report.pdf.

47 Customized Energy Solutions et al. July 2017. Massachusetts Department of Energy and Resources (DOER) and Massachusetts Clean Energy Center (MassCEC). State of Charge, p. 174. Available online: http://www.mass.gov/eea/docs/doer/state-of-charge-report.pdf.

48 Federal Energy Regulatory Commission. February 15, 2018. "FERC Issues Final Rule on Electric Storage Participation in Regional Markets." Available online: https://www.ferc.gov/media/news-releases/2018/2018-1/02-15-18-E-1.asp#.WrNpmyIxWEc.

49 Denholm, Ela, et al. 2010. National Renewable Energy Laboratory. "The Role of Energy Storage with Renewable Electricity Generation." Available online: https://www.nrel.gov/docs/fy10osti/47187.pdf.

50 Customized Energy Solutions et. al. July 2017. Massachusetts DOER and MassCEC. State of Charge . Available online: http://www.mass.gov/eea/docs/doer/state-of-charge-report.pdf.

PHOTO CREDITS

Front Cover: © iStockphoto/gorodenkoff

Pg. 3: © iStockphoto/xijian

Pg. 4: © iStockhpoto/c1a1p1c1o1m1

Pg. 5: © NREL/Dennis Schroeder

Pg. 8: © iStockphoto/Petmal

Pg. 9: © iStockphoto/Olivier Le Moal

Pg. 11: © NREL/Sunpower

Pg. 13: © NREL/Dennis Schroeder

Pg. 16: © Creative Commons/Tim Sackton

AN OVERVIEW OF ENERGY STORAGE OPPORTUNITIES FOR MASSACHUSETTS COMMERCIAL BUILDINGS

A BETTER CITY
33 Broad Street, Suite 300
Boston, MA 02109
617.502.6240
www.abettercity.org